BANGALORE WATER SUPPLY & SEWERAGE BOARD

"PROJECT REPORT"

IMPLEMENTATION MEASURE OF ENERGY SAVING OPPORTUNITIES AT BWSSB WATER PUMPING INSTALLATIONS

(As per the findings of TERI's Energy Audit Report)

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IMPLEMENTATION MEASURE OF
ENERGY SAVING OPPORTUNITIES
AS PER ENERGY AUDIT REPORT OF TERI
on
BWSSB WATER PUMPING INSTALLATIONS

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PROJECT FEATURES

1.	**Name of the work**	a)	Investment in energy saving opportunities at BWSSB pumping stations
		b)	Renovation and modernisation of metering / Annunciation / protection / start-up gear system of pumping stations
2.	**Agency**	:	BWSSB
3.	**Time of completion of work**	:	2 Years
4.	**Cost of the scheme**	:	For 1a) above : Rs.932.75 lakhs
		:	1b) above : Rs.737.25 lakhs
			Total Rs.1670 lakhs

CHAPTER - I

EXECUTIVE SUMMARY

1.0 Purpose

The purpose of this ***'Feasibility report'*** is to identify technically feasible and cost effective schemes to improve the energy efficiency and energy conservation at BWSSB pumping stations. These include certain urgent renovation and modernisation measures required to be taken to help O&M staff to operate the major pumping stations in a much smoother way. All these measures are expected to help in achieving a goal of "rational use of energy" leading to lowering of energy costs, thus improving the profitability of the Board as a whole.

2.0 Conclusions and Recommendations

The quick implementation of energy saving opportunities for BWSSB as suggested by TERI, as part of energy audit, is the best course of action in view of :

(i) This will lead to "rational use of energy", there by accounting for reduced energy costs. This is very important considering ever-growing cost of energy and energy cost component in the water tariff which is very high for BWSSB (in view of high head application).

(ii) This has given opportunity to induct new technological measuring instruments protection, controls and start-up gear etc., which could be classified under renovation and modernisation. Stage-I and II works were completed 23/15 years and majority of metering , relays and control & protection items have become sluggish. These are not helping O&M staff to run the station on day-to-day basis. This would lead to additional energy saving upto 5% in certain cases. The microprocessor technological equipment will not only help in overall monitoring of the station but also provide data to the operational staff/management. In the long run, all these will give added advantage in improving overall efficiency of the system especially when resources are scare.

(iii) Considering ever-growing demand, better performance of the pumping station and also considering balance life cycle of the pumping system, all these measures are very essential and accounts for mid term corrective action to achieve expected overall efficiency level.

(iv) Benefits obtained from "reduced energy charges" are sufficient to offset the required investment. The simple payback period for replacement of pumps requiring high investment is only 6 months.

(v) It is possible to get designed flow of water (10% more than present level) from Stage - I and II pumps, thereby improved revenue the Water Board.

3.0 Project Implementation Schedule

Considering the present level of efficiency figures for the pumps and requirement of deletion of outdated technological metering/ protection/control equipments, it is considered necessary to complete all the action within two years period. The broad stages could be as follows :

(i) Appointment of consultants in the required area

(ii) Preparation of specifications of motors/pumps/other equipments covered by renovations and modernisation and drawings including furnishing of existing facility.

(iii) Identifying probable supplier and pre-qualification of the contractors.
(iv) Invitation bids
(v) Evaluation of tenders
(vi) Award of contract for supply/erection
(vii) Supply/erection/commissioning
(viii) Overall monitoring of improvements achieved

The project will be implemented in a complete manner in the next 15-24 months.

4.0 Project Cost

The broad break-up of investment required for energy saving opportunities is estimated at **Rs.932.75 lakhs** and where as renovation and modernisation estimated at **Rs.737.25 lakhs**, totalling to **Rs.1670.00 lakhs**. This cost is based on Oct 97 rates and includes contingencies, IDC and provision towards escalation. As the Cauvery works of Stage I , II and III were executed through different contracting agencies, under the supervision by the Board staff in the present estimate also, no loading on account of supervision of works is proposed. For implementation measure a provision for appointment of consultant in the desired area of Board has also been made.

5.0 The detailed base capital cost break-up is covered under Chapter - VII.

6.0 Benefits

The "**annual energy savings**" by implementing the measures at major stations, is with present rate of KEB tariff for energy and demand estimated to be Rs.748.68 per annum from 2nd year onwards when implementation measures are completed. However, considering the likely revision or KEB tariff by 13% in coming years, the annual saving will improve further to that extent annually.

Though the benefits accruing from modernisation of certain aspects of metering, protection, control devices etc cannot be exactly quantified, it is estimated that this measure could lead to energy savings upto 5% in certain cases and an aid in improving overall efficiency of the plant as a whole (which is not quantifiable in terms of money)

CHAPTER - II

PROJECT BACKGROUND & HISTORY

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PROJECT BACKGROUND & HISTORY

2.1 Introduction

Bangalore Water Supply and Sewerage Board was formed by an act of Legislature during 1964. The Boards is entrusted with the general duty of providing supply and improving the existing supply of water in the Bangalore Metropolitan area and of making adequate provision for the sewerage and the disposal of the sewage in the Bangalore metropolitan area. The Board is a local body of the Karnataka State under the Ministry of Housing & Urban Development. As per the provisions of the Act, it is the duty of the Board to take steps from time to time

a. For ascertaining the sufficiency and wholesomeness of water supplies within the Bangalore metropolitan area.

b. For preparing and carrying out schemes for the supply of wholesome water for domestic purposes within the Bangalore Metropolitan area.

c. For preparing and carrying out schemes for the proper sewerage and the disposal of the sewage of the Bangalore metropolitan area.

2.2 During the year 1966, the BWSSB with a view to augment the water supplies to the city from a dependable source, sought World Bank assistance and prepared Master plans and project report as per the norms fixed by the World Bank authorities. M/s Binnie and Partners (India) Ltd, was the agency who prepared the report after a detailed study. Accordingly, the augmentation of supplies from River Cauvery (which is the most dependable source) to an extent of 540 MLD (156 MGD) was taken up in stages was contemplated.

2.3 The Board took up the Cauvery 1st phase of the project on its own to bring in a supply of 135 MLD of water to the City, for execution during the later half of 1969 and successfully commissioned in 1974. To further augment the supply, the Board took up the second stage of the Scheme for execution during 1979 and commissioned it in July 1982. The additional augmentation in supplies was to an extent of 135 MLD.

2.4 For the Cauvery I and II stage schemes, the assistance of Stage Government, Central Government (under plan schemes) and LIC was obtained to cover the entire cost of the project.

2.5 For the Cauvery III stage scheme, envisaging an additional supply of 270 MLD of water to the city at an estimated cost of Rs 270 crores, the Board has executed the project on its own as was done for the I and II stage schemes. In addition to the assistance from State Government, loan from LIC, HUDCO, Railways, Defence Establishment (Government of India), Bangalore City Corporation, Bangalore Development Authority have been obtained to cover the cost of the Project.

2.6 The earlier population projections of this City estimated by different agencies have gone haywire. During the decade 1971-81, the population increased by 76%. The Bureau of Economics and Statistics, Government of Karnataka had estimated a population of 23 7 lakh in 1980 But the population of the City as per 1981 census was 29.15 lakh. The Town Planning and Metropolitan Authority, Government of India had projected a population of 38 lakh by 2001. But the population in 1991 has already outstripped the above figure and is in the range of Rs.41 lakh as per census The trend indicates that the rate of population growth may be fast for another two decades.

2.7 Bangalore City is developing very fast as the city is blessed by good environmental conditions. The city is surrounded by an industrial belt, having many private and public sector industries, apart from Defence establishments and reputed educational institutions. It is connected by rail, roads and air and has become a big business centre. The population is diverse and comprise industrial workers, business men, labourers, office-goers, etc. The literacy level is quite high except in slums and other areas inhabited by the economically weaker sections. Public are aware of the changing environment and social atmosphere. People are quite conscious about the health hazards caused by water pollution and environmental pollution.

2.8 As in case of power sector, the demand and supply gap is widening even in case of water supply scenario. This under scores the need for taking up schemes for further optimising of water supply to the city from existing reservoir. The present level of consumption of water for domestic uses, is arrived as at around 100 LPCD after allowing for distribution losses against standards of 150 - 200 LPCD as per CPHEEO. The present industrial supply which is around 50 MLD is expected to be doubled by the end of year 2000.

2.9 The estimated gross per capita water consumption of Bangalore during the past four years were as follows:

Year	LPCD
1994-95	151
1993-94	157
1992-93	101
1991-92	105

2.10 Considering CPHEEO norms of 150 - 200 LPCD, the demand and supply position for 1995-96 were estimated as follows:

(In MLD)

Demand : 850
Supply : 600

Gap (-) 250

2.11 By 2000 and 2010, the restricted water demand and supply position is expected to be as follows:

Year	Demand, (MLD)	Supply, (MLD)	Deficit	
			MLD	%
2000	964	642	322	33
2010	1187	912	298	25

2.12 Thus it is evident from the above, inspite of best efforts by Board to augment additional supply from existing sources, the gap in the future years is likely to continue and as such the Board, which is the sole agency is responsible for the implementation of the water project has initiated good measure of not only taking action for identifying the wastage/leaks of both water and power but also to take initiative on '**Demand Side Management**'.

2.13 Considering these, as a first step, BWSSB has identified to have a comprehensive 'energy audit' of all main water stations and also for city distributories for Cauvery and Arkavathy basins

2.14 TERI was assigned with energy audit study during February 1997 on the basis of the agreement entered between BWSSB and TERI This covered all the major pumping stations of T K Halli, Harohalli, Tataguni of Cauvery stage-I, II and III works and also Arkavathy zone consisting of Soladevanahalli, T G Halli and Tavarekere. The city distributory network was also included

A 'draft report' was submitted to BWSSB during May '97 for their review of comments and suggestions to enable to finalise the report. Based on the subsequent discussions/clarifications with Board officials, the report was accepted, enabling TERI to send the final report during August 1997.

2.15 The findings of TERI report mainly gave the recommendations on :

- efficiency performance figures
- energy saving opportunities at various installations
- improved operating practices
- renovation & modernisation aspects.

TERI had also furnished summary of potential energy savings potential as per which if various measures are implemented, these would be cost savings of about Rs.7.48 crores per annum with the present rate of KEB units, with simple payback period of less than 6 months in most of the cases.

2.16 The recommended measure is the replacement of inefficient pumps in the system and also renovation and modernisation aspect of the major pumping station, there will be direct/indirect benefits to BWSSB, thus BWSSB has decided to implement the measures at the quickest possible time.

2.17 BWSSB have retained the services of M/s.TERI to prepare the feasibility report for implementation of energy savings opportunity measures as recommended by TERI in the energy audit report on water installations.

CHAPTER - III

WATER & ENERGY SCENARIO OF BWSSB

CHAPTER - III

WATER & ENERGY SCENARIO OF BWSSB

3.1 Present Water Scenario

BWSSB which caters to the water supply and sewage disposal needs of the metropolitan city of Bangalore gets water from two river sources:

- Arakavathy (including Hesaraghatta)
- Cauvery river.

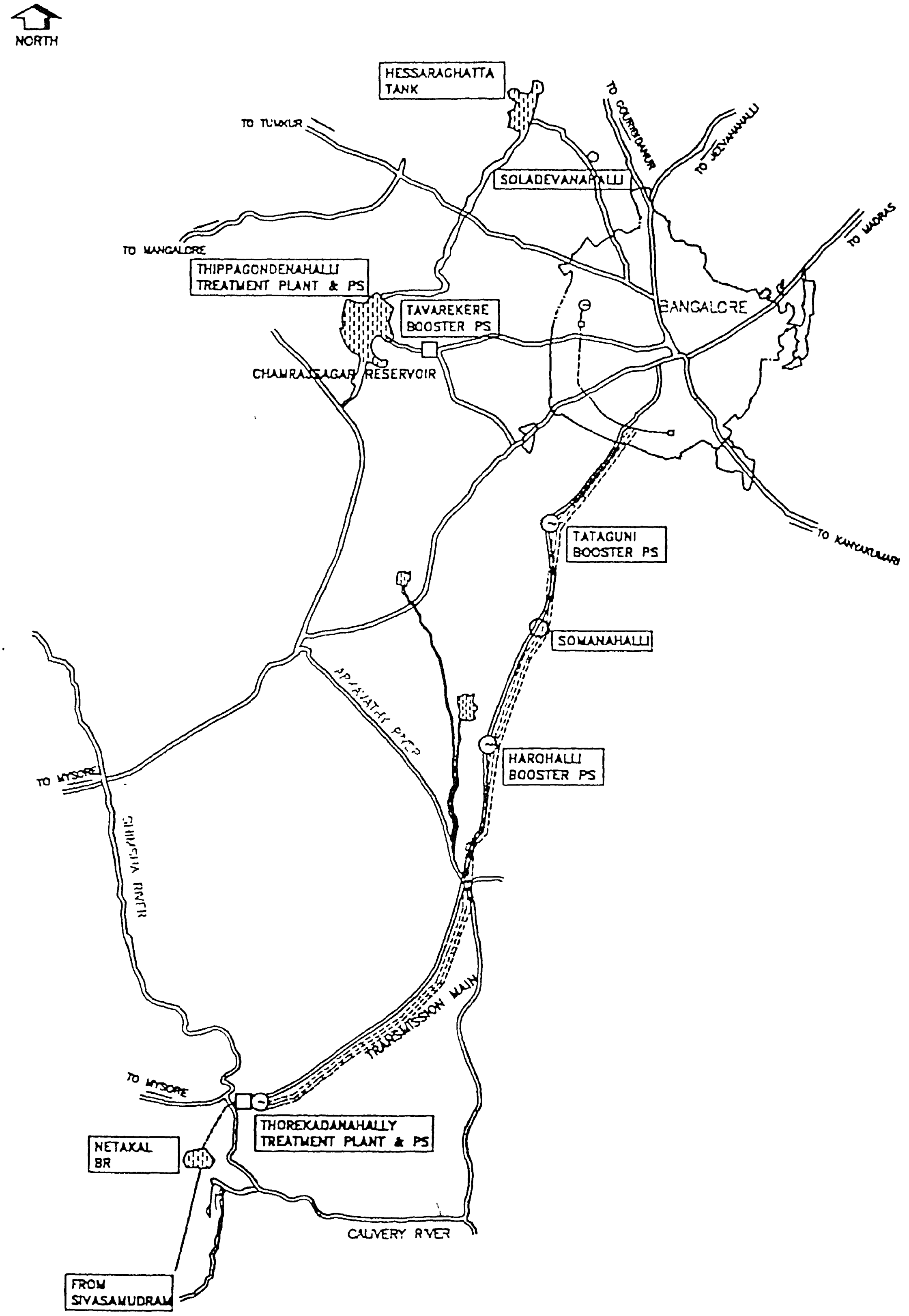
3.2 The first scheme of water supply was from the Hesaraghatta reservoir (18 kms) across the river Arakavathy which was commissioned during from 1896. Due to the increasing demand of water, due to rapid growth of city, a dam across Arakavathy near T G Halli about 28 kms down stream of Hesaraghatta was made ready during 1933. T G Halli water is pumped to the city against a head of 272 m in two stages. Tavarekere is the intermediate pumping house with Stage-I works. 27 MLD of water was drawn when city population was 3.0 lakhs. This was raised to 48 MLD during 1951 when the population was 10.0 lakhs With additional improvement, it was further stepped upto 72 MLD by 1958-59. By 1964, an additional stage was created to have about supply of about 135 MLD.

3.3 With population increasing to 15 0 lakhs by 1967, tapping of Cauvery was planned By January 1974, stage-I of Cauvery supplied 135 MLD water. Stage II of similar 135 MLD capacity was added by 1982 and 270 MLD by 1993 Thus Cauvery zone has a built-up capacity of 540 MLD The total pumping head is 510 m from pump house at T K Halli to Tataguni. Harohalli is the intermediate pumping station.

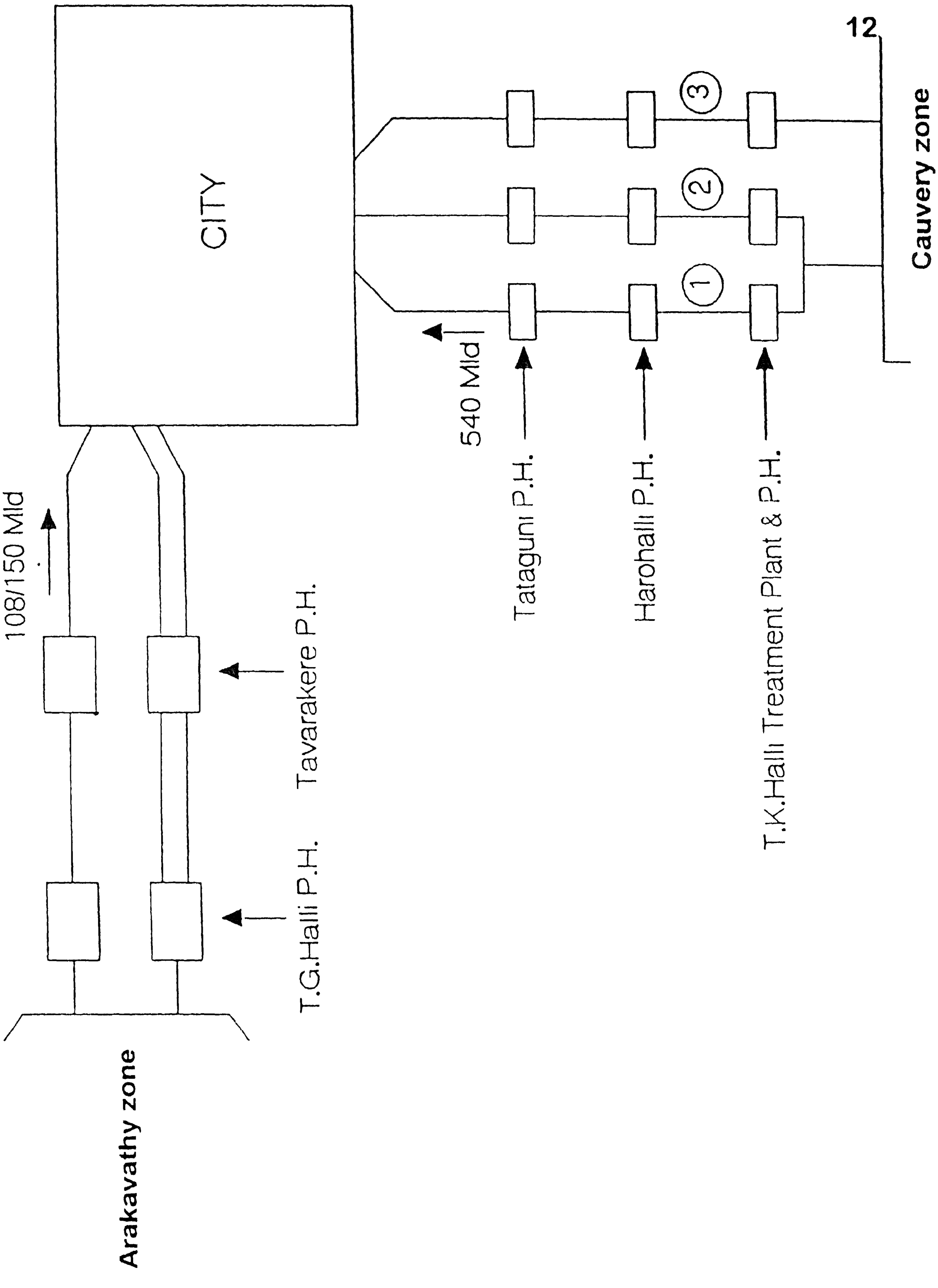
3.4 Presently, Arakavathy zone stations are under renovation and 150 MLD of water is expected to be available after rehabilitation. A schematic diagram and installed capacities of main transmission lines of two sources of water and pumping stations are as follows:

Table : 3.4

Sl No.	Location	Capacity in H P.	No. of pumps
1.	Soladevanahalli	240 220	3 1
2.	T G Halli	2000 1000 530	3 4 6
3.	Tavarekere	530	6
4.	**Cauvery I stage**		
	a. T K Halli	1675	5
	b. Harohalli	1675	5
	c. Tataguni	1675	5
	d T K Halli (filter house)	75	2
5.	**Cauvery II Stage**		
	T K Halli	1675	5
	Harohalli	1675	5
	Tataguni	1675	5
	T K Halli (filter house)	75	2
	Shimsha	175	3
6	**Cauvery III Stage**		
	T K Halli	2000	8
	Harohalli	2000	8
	Tataguni	2000	8



EXISTING BANGALORE WATER SUPPLY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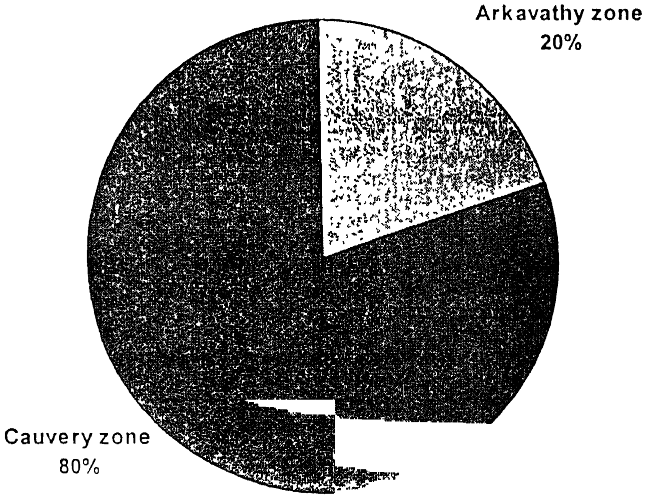
CITY
108/150 Mld
Tavarakere P.H.
T.G.Halli P.H.
Arakavathy zone
540 Mld
Tataguni P.H.
Harohalli P.H.
T.K.Halli Treatment Plant & P.H.
①
②
③
Cauvery zone

3.5 Present Share of Mix of Two Sources of Water

On the review of the studies of water supply potential and availability as of 1993-94, the broad break-up of the two water source constituents in terms of potential and availability of water were in the ratio of 80 20 as detailed below :

Sl No.	Zone	Potential MLD	Availability MLD	% of potential
I	**Cauvery zone**	**540**	**514**	**80**
i	Stage I (1974) + II (1982)	270	257	40
ii	Stage III (1993)	270	257	40
II	**Arkavathy zone (1933)**	**140**	**115**	**20**
Grand Total		680	629	100



Thus, it is evident that as Cauvery zone has 80% potential, requiring a closer look for energy saving opportunities when compared to the Arkavathy zone.

3.6 Details for Cauvery Zone Stations

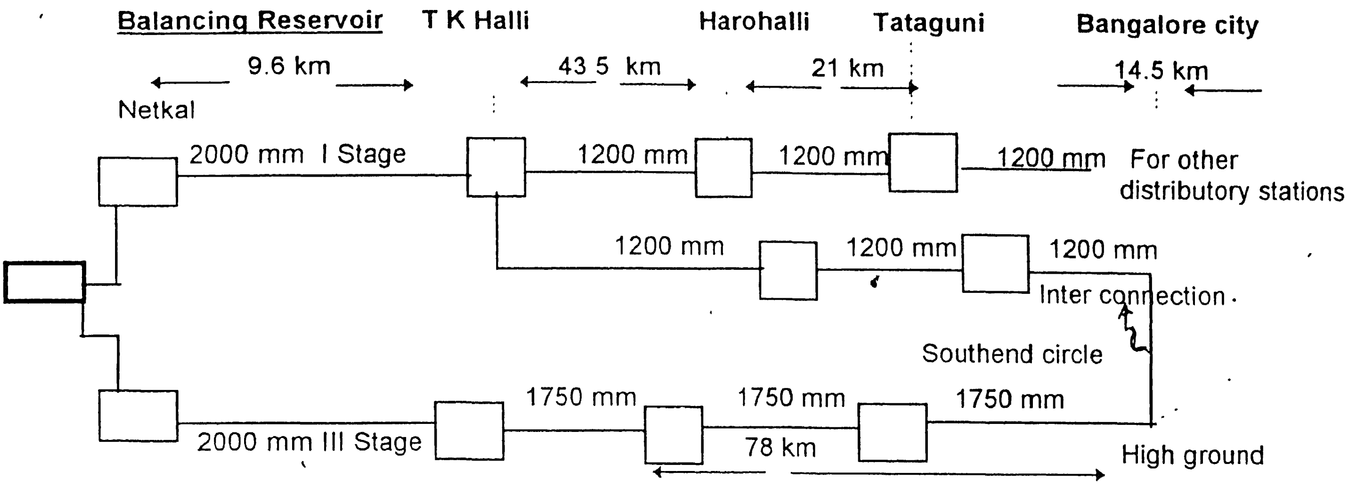
3.6.1 BWSSB has developed three stages of Cauvery pumping stations with the year of completion as follows:

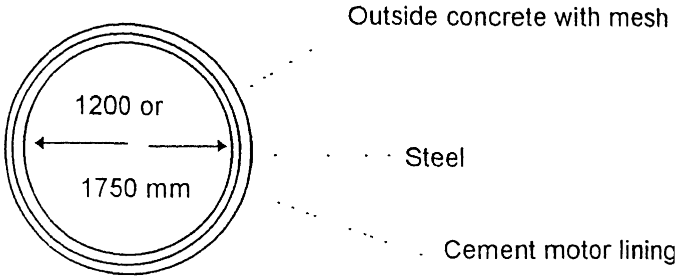
Stage	Capacity, MLD	Year of Completion	Age (years)
I	135	1974	23
II	135	1982	15
III	270	1993	4
Total	540		

3.6.2 Intake of Water for Cauvery

The water intake point is Cauvery river at Shivanasamudra Anecut (which is also an intake for KEB Shiva hydro station) There is a balancing reservoir called Netkal. Water is drawn from this Netkal reservoir and conveyed through gravity main of 9 6 km to the water treatment plant at T K Halli There are gravity main feeding to stage-I, II and III stage. There are three main pumping stations located at places called T K Halli, Harohalli and Tataguni.

3.6.3 Distances of Transmission mains at Cauvery Stations (Stage I, II & III)





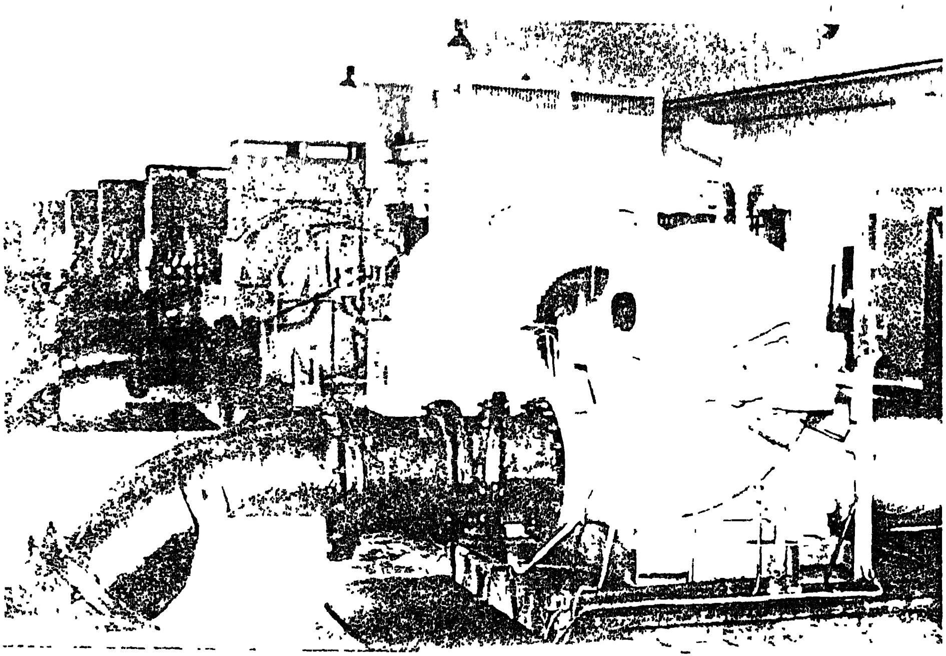
Cross section of a transmission n

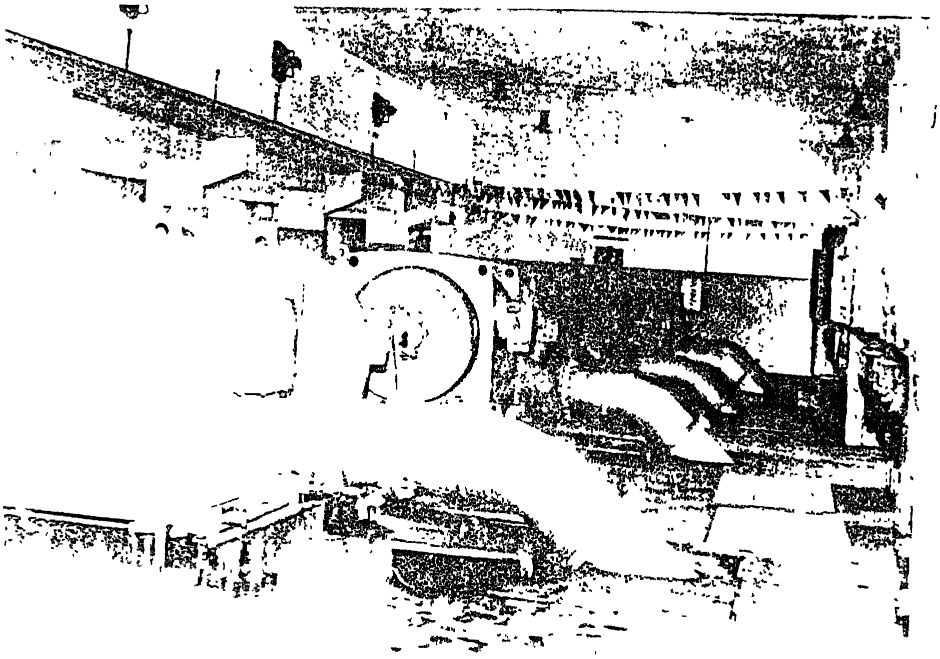
3.6.4 PUMPING UNITS AND PUMP HOUSE

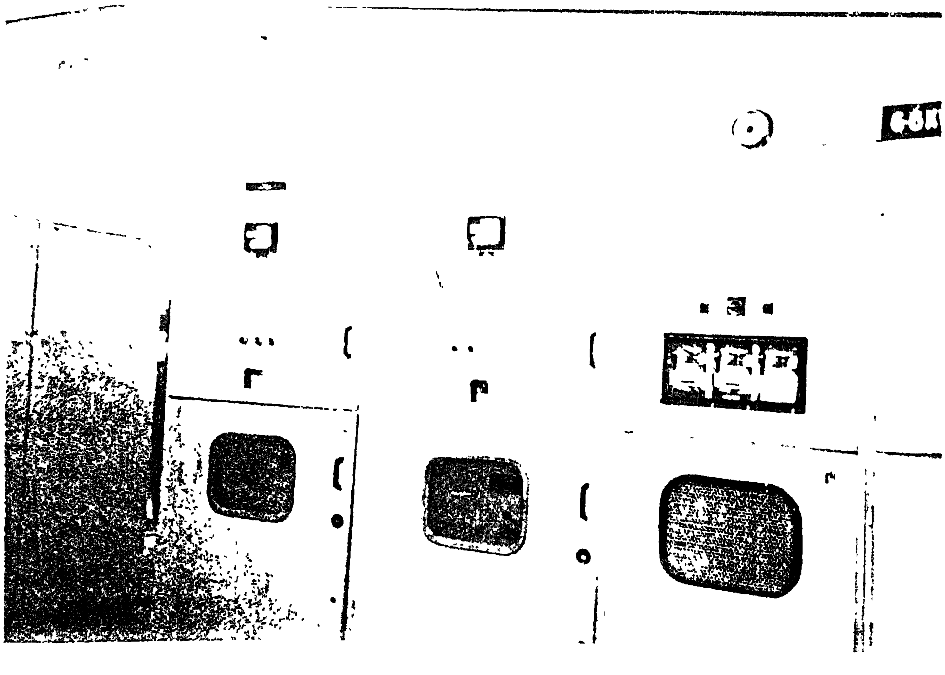
The system of BWSSB pumping is unique in view of high head and high discharge requirements. At three locations of T K Halli, Harohalli and Tataguni, the details of I and II stage pumps and motors are as follows·

Pumps	I Stage	II Stage	III Stage
Pump make	Mather & Platt	Mather & Platt	M&P
Type			EME-H-DV
Discharge	10 GD/6950 GPM	10 MGD/6950 GPM	54 MLD/2250 LPS
Head, m	160 /170	170	160/170
Efficiency, %	82	82	88
Serial No	711064/M/10	711064/M/10	881107/M/8
Motors			
Make	BHEL, Az-14-59-4T, Haridwar	NGEF	NGEF
Type	Squirrel cage, AC-3, Induction	Squirrel cage, 630M4, Induction	Induction, A-630 LK-4
Insulation class	'B'	'B'	'F'
Voltage, kV	6.6	6.6	6.6
rpm	1490	1488	1492
Amps	127	120	157
HP/kW	1675/1250	1700/1250	2040/1500
P F	0 9	0 9	0.89
η_m	95 2		
Auto-trfr start-up position	85% tap	85% tap	85% tap

There are provisions for inter-linking of the mains at different places especially for stage I and II. The mains are of steel with inside cement mortar lining with an assumption to achieve Hazen Williams constant C-100 and has also external cement mortar coating with steel wire mesh







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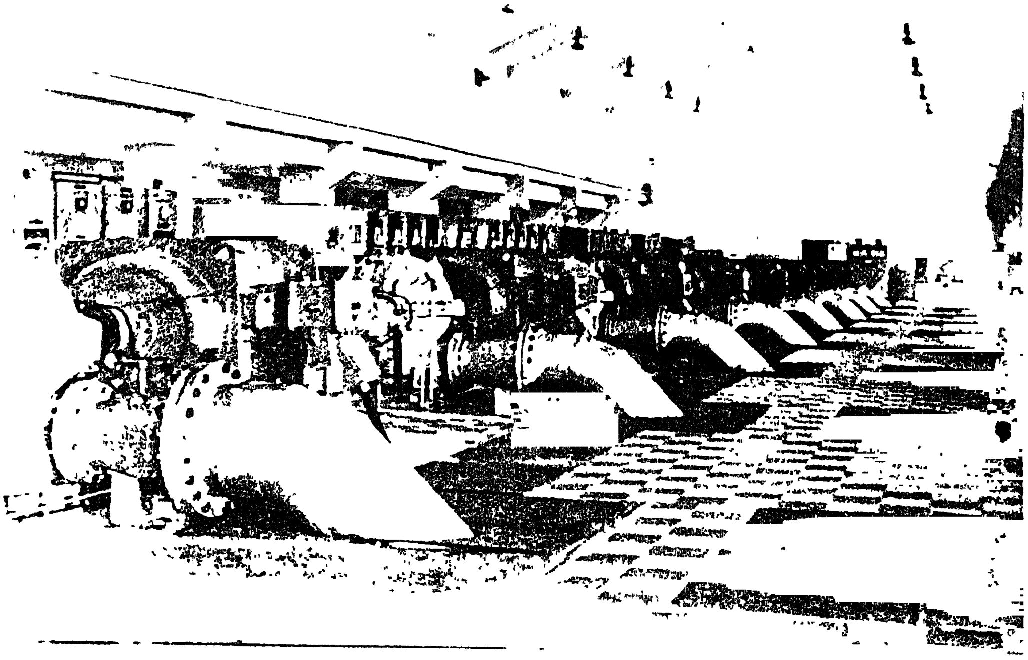

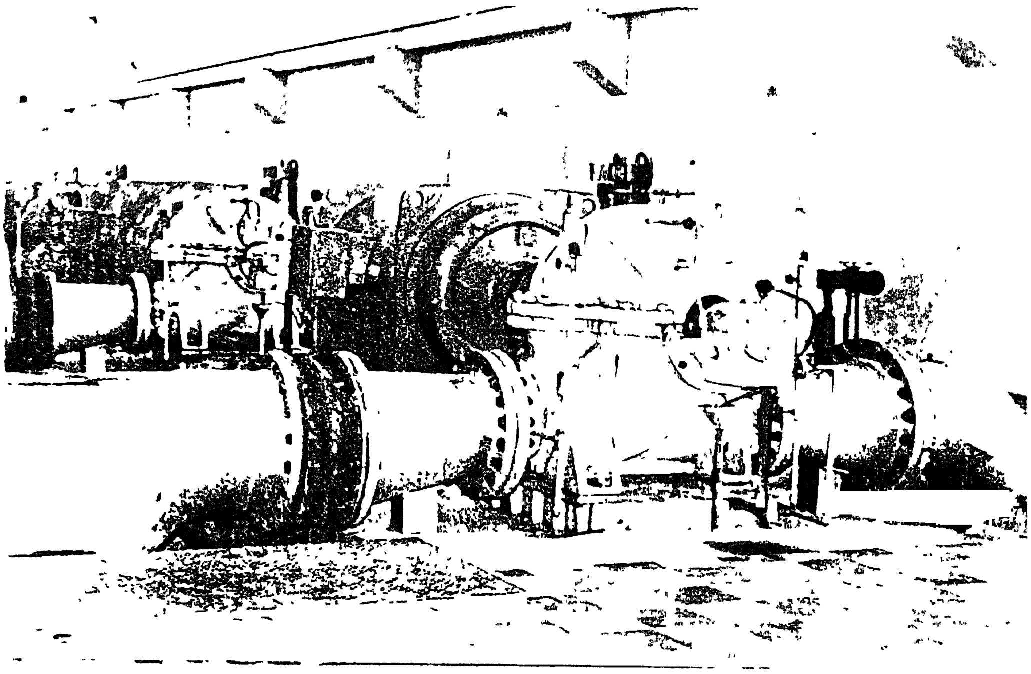

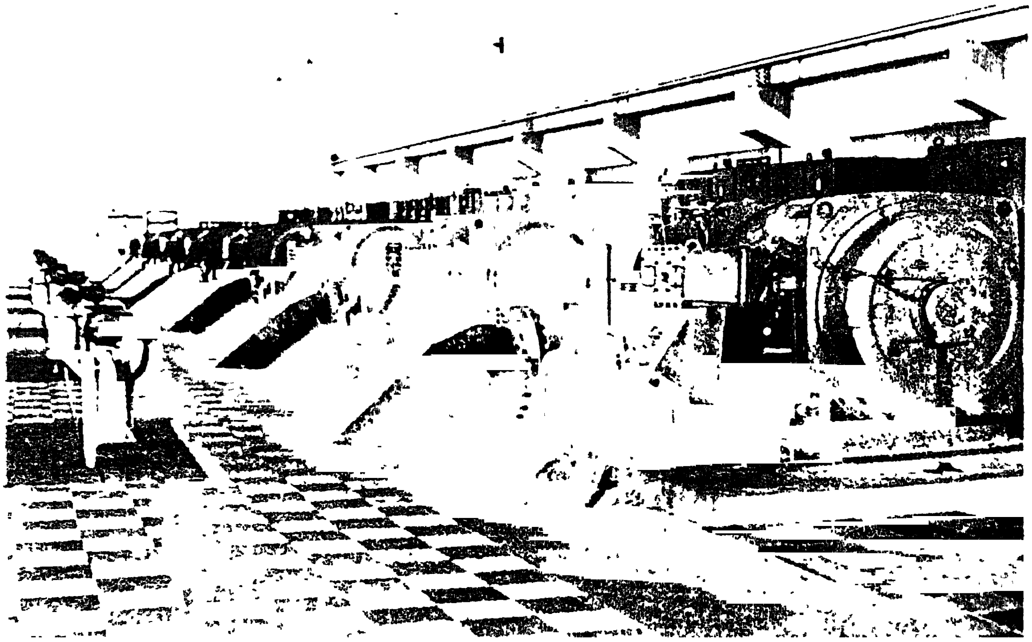

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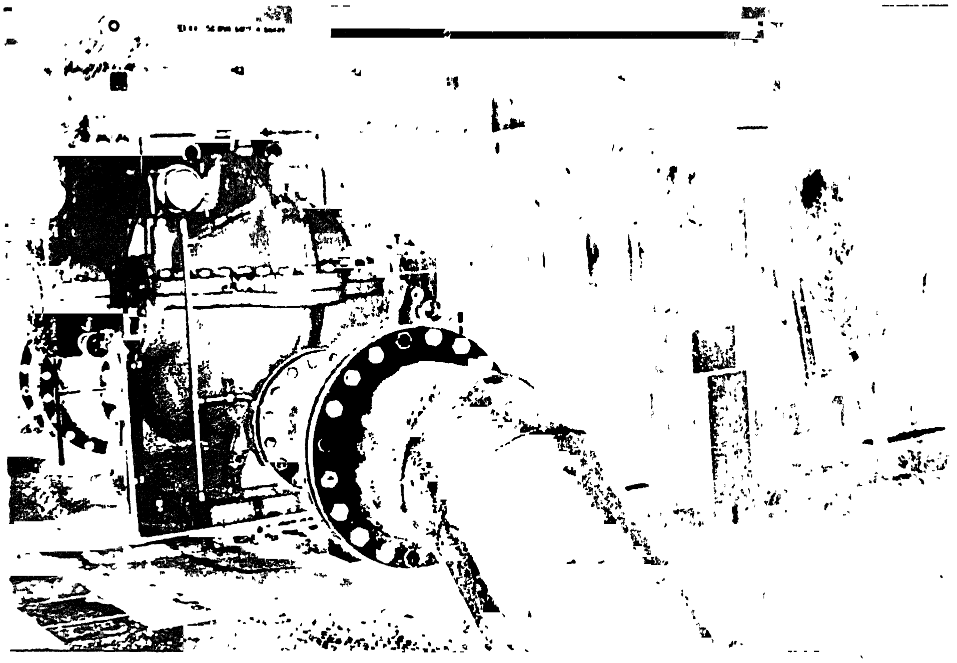
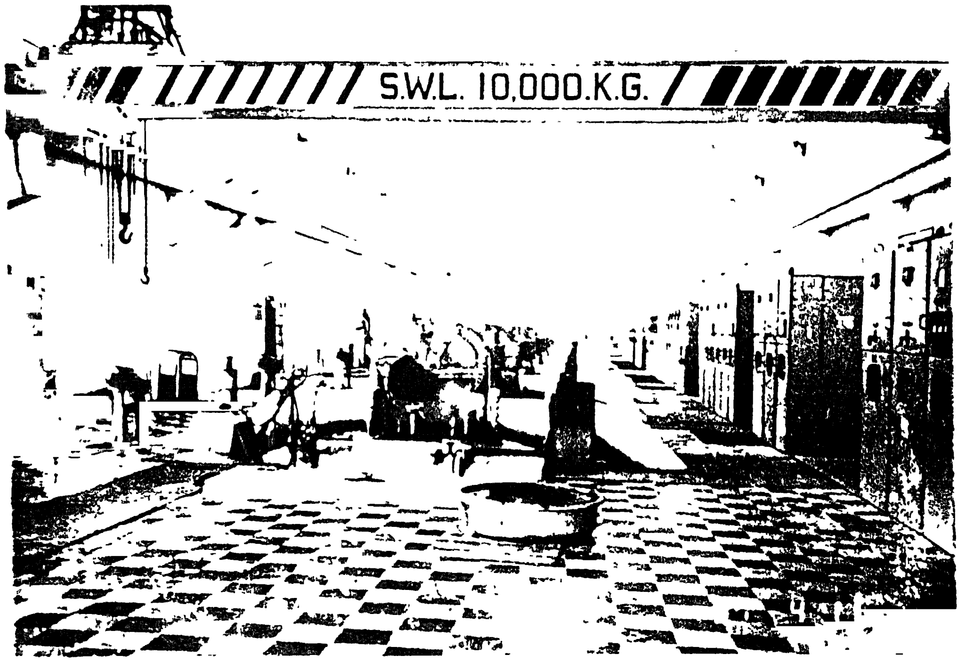
ADDITIONAL VIEWS OF CAUVERY III STAGE





3.6.5 Comparative Discharges of each Pump in Different Units

Stage Pump/Manifold	I & II		III	
	Pump	Manifold	Pump	Manifold
MGD	10	30	12	60
MLD	45	135	54	270
GPM	6950	20850	8340	41700
m^3/h	1875	5625	2250	11250
LPS	521	1562	625	1875

3.6.6 Number of Pumps Working at each Main Station (Normal)

Stage	No. of pumps Installed at each station	Under normal condition		
		Pumps working	kW	Discharge, MLD
I	5	3	3750	135
II	5	3	3750	135
III	8	5	7500	270
Total	18	11	15000	540

The above configuration of working of pumps is uniform for all the three stations of T.K.Halli, Harohalli and Tataguni.

3.6.7 Loading at Normal Operating Condition

For Cauvery Zone stations the normal operating condition with rated kW/HP of motors are follows:

T K Halli, Harohalli, Tataguni Stations				
Cauvery Zone	Stage-I	Stage-II	Stage -III	Total
No. of pumps run	3 Nos.	3 Nos.	5 Nos.	11 Nos.
Each Motor kW/HP	1250/1675	1250/1700	1500/2040	
Total load kW/HP	3,750/5,025	3,750/5,100	7,500/10,200	15,000/20,325

Thus, out of (3x5)+(3x5)+(3x8) = 54 pumps, normally 3x(3+3+5)=33 nos. work. Hence, at any time the normal loading of 3 stations together will be 45000 kW.

3.6.8 Pipe Size at each Pump Outlet and Main Manifold

	Stages	I & II	III
I	a. Pump outlet pipe ID mm	450	600
	b. Cross sectional area, Sq. m	0.159	0.2827
II	a. Main manifold, mm	1200	1750
	b. Cross sectional area, Sq mm	1.13097	2.4052

The total length of pipe work from T K Halli to Bangalore is about 93 kms with total elevation difference of 500 m.

3.6.9 Energy Consumption Trends:

The following table furnishes the range of power consumption figures on kVA & energy during the last one year.

	kVA Demand		Energy (lakh units)	
	Stage-I, Max - Min	Stage- II & III Max - Min	Stage-I Max - Min	Stage- II & III Max - Min
T K Halli	5520-4500	13440-11760	29 10-22 87	72 85-61.89
Harohalli	4560-3847	12540-10320	23.8-20.95	67 07-60.21
Tataguni	4560-3847	12540-10320	24 88-22.72	70.86-48.61

3.6.10 The daily average consumption of three major station is on the basis of Dec'96 approximately as follows:

lakh units

Station	Stage-I	State II & III	Total
T K Halli	0.85	2.19	3.04
Harohalli	0.70	2.02	2.72
Tataguni	0 75	2 13	2.88
Total			8.64

Thus based on the above, the annual energy consumption works out to 3154 lakh units (or 315.4 MU per year). In case of Arakavathy zone, the motor loads together works out to 7500 kW. The annual energy consumption for 3 major stations on annual basis will go upto 480 MU per year, if sufficient water is available in the reservoirs.

Thus, in view of high head application the Bangalore water supply scheme could be classified under most energy intensive group.

.7 City Distributory

There are totally 35 distributory stations, out of which 28 nos. of pumping stations feed directly to the consumer areas and 7 nos. either fill over head tank or feed to distributory system directly. The total installed capacity of 35 pumping stations is 7270 HP, out of which 2875 HP capacity is built-in in the system as standby. The operating hours of each station vary dependant on the water storage/area of spread etc All stations have 440 Volts motor with ratings and their nos as follows

3.7.1 Rating of motors at various category

Sl.No	Capacity of Motors	Nos.	Installed Pump Stations
i	250/240 HP	6	2
ii	150 HP	7	2
iii	100/90 HP	22	8
iv	75 HP/85 HP	6	3
v	60 HP	8	5
vi	50 HP	29	15
vii	40 HP	4	2
viii	25 HP	2	2
	Total	**84**	

3.7.2 Operating Loads

The following table furnishes the names of pump houses with installed capacity, standby details and operating load details of the city distributory station.

Pump House No	Name of the Pumping Station	Installed Capacity	Standby Details	Operating Loads (HP)
1	Highground			
2	Pump House - I	3x250 HP	1 stand by	2X250
3	Pump House - II	4x100 HP	1 stand by	3 X 100
4	Miller Road	1x60 HP 1x50 HP	1 stand by	1 X60
5	LLR Pump House - I	3x100 HP	1 stand by	2 X100
	Pump House - II	2x50 HP	All run	2 X 50
6	Hosahalli	1 x 250HP + 2 x 240 HP	1 stand by	2 X 250
7	Magadi Road (overhead tank)	2 x 50 HP	1 stand by	1 X 50
8	West of Chord Rd (overhead tank)	2 x 50 HP	1 stand by	1 X 50

Pump House No	Name of the Pumping Station	Installed Capacity	Standby Details	Operating Loads (HP)
9	Banashankari	2 x 60 HP 2x100 HP 1x150 HP	1 stand by 1 stand by Extra	1 X 60 1 X 100
10	Mount Joy	3 x 50 HP	1 stand by	2 x 50
11	Basavangudi	2x60 HP	not in use	Booster Pump
12	Indiranagar (overhead tank)	2x40 HP	1 stand by	1 X 40
13	Koramangala (overhead tank)	2 x 50 HP	1 standby	1 X 50
14	Ulsoor	2x75 HP	1 stand by	1 X 75
15	Banappa park (overhead tank)	2 X 50 HP	1 stand by	1 X 50
16	Domlur (overhead tank)	1x50 HP	-	1 X 50
17	HAL Aero-engine - I	2x90 HP	1 stand by	1 X 90
18	OMBR, Machalibetta	4x100 HP	2 stand by	2 X 100
19	ITI, Machalibetta	2x50 HP	1 stand by	1 X 50
20	Chikkalalbagh	1x60 HP		1 X 60
21	Jayanagar Market Complex (Overhead tank)	1x50 HP 1x75 HP	1 stand by	1 X 75
	Johnson market			
22	Pump House - I	2 x 90 HP	1 stand by	1 X 90
23	Pump House - II	2 x 90 HP	1 stand by	1 X 90
24	Malleswaram (CJF)	4x150 HP + 1 X 85 HP + 2 X 60 HP	Two not running 1x150+1x170	3 X 150 + 1 X 85 + 2 x 60
25	Tata Institute (Malleswaram)	2x50 HP	1 stand by	1 X 50
26	BEL Pump house (Malleswaram)	2x50 HP	1 stand by	1 X 50
27	Yelahanka (Malleswaram)	3x100 HP	1 stand by	2 X 100
28	[illegible] Machibetta (Malleswaram)	2x50 HP	1 stand by	1 X 50
29	Malleswaram office complex and filling point	1x25 HP	-	1 X 25

Pump House No	Name of the Pumping Station	Installed Capacity	Standby Details	Operating Loads (HP)
30	HGR & KGT Pump house (Malleswaram)	2x150 HP	-	2 X 150
31	Jayanagar T Block (Overhead tank)	1 X 50 HP 1 X 25 HP		1 X 50 1 X 25
32	K.G.Tower	2 X 40 HP	Not running	-
33	Vijayanagar	2 x 50	1 standby	1 x 50
34	OHP	2 X 50	1 standby	1 x 75
35	Yelahanka	2 x 75 HP	1 standby	1 x 75
Total of 35 Stations		**7270 HP (84 Nos.)**	**2875**	**4395 HP (49 Nos.)**

3.7.3 Energy Consumption Trends for city stations:

The distributory stations energy consumption and power charges are as follows:

Year	Lakhs Units	Power Charges, Rs lakh
1993-94	47.73	64.50
1994-95	39.96	64.77

3.8 Total annual power charges of BWSSB during the past two years are as follows

Year	Rs (crores)
1994-95	129 32
1995-96	154 83*

* includes arrears

CHAPTER - IV

ENERGY CONSERVATION & ENERGY AUDIT

CHAPTER - IV

ENERGY CONSERVATION AND ENERGY AUDIT

4.1 Introduction

Electricity is a very expensive form of energy. This is because electricity is a secondary form of energy derived from primary fuels like coal, oil and gas. In India and world wide the generation mix are as follows :

Data	India	World wide
Thermal	70%	65%
Hydro Electric	25%	17%
Nuclear & others	17%	18%

The following factors must be kept in mind by users of electricity :

(i) Efficiency of thermal generation is quite low around 30-35% Thus by burning 3 units of primary fuel one unit of electricity is produced.

(ii) Transmission and distribution losses account for 20% - 25% of electricity generated. Thus 1 unit of electricity at user industry requires 4 units of primary fuel. Each unit of electricity saved leads to saving of 4 units of primary fuel.

(iii) Setting up power stations is very expensive It costs Rs.4 to 5 crores per MW Transmission and distribution adds additional costs Conservation projects to save electricity can be set up at much lower costs.

(iv) At any time demand and supply of electricity has to match instant to instant. The nature of electricity peak demand in day may be at least 30% more than the off peak periods Controlling of peak demand is very important for electricity conservation.

4.2 Scope of Efficiency Improvement

During last 20 years, in developed countries, the total energy consumption has increased just by 20% in 20 years. Whereas in developing countries it is almost grown up by 300%. The main reasons for these differences are

Sl No	Data	Developing Countries	Developed Countries
i.	Population increase	Sharply increasing	Stabilised
ii.	Energy intensive growth industries	Rapidly expanding	!
	Manufacturing technology	Use inefficient	Use highly energy efficient technologies
iii.	Rise energy consumption for 1% rise in production	20% more	-Nil-
iv.	Energy efficiency improvement	Comparatively low	35-40% in all the sectors in last 20 years
Eg	a 165 litre refrigeration model consumes	600- 700 units per annum	250 units per annum
	b Steel plants	9 - 10 Gcal/ton of steel	5 to 6 Gcal/ton of steel
	c Aluminium	16000 - 19000 kWh	12000 - 14000 kWh
	d Fertiliser	9 - 12 Mkcal	6 - 7 Mkcal
	e Pulp and paper	11 - 12 Mkcal	7 5 - 8 0 Mkcal

4.3 Energy Efficiency and Energy Management

It must be remembered that electricity is used any plant for four basic functions.

i Motors and drives (About 70%) and others, like electric heating, melting, electrolysis, etc (About 20%)

ii Illumination (About 10%)

Motors are used to drive equipments like pumps, fans, compressors etc. Motor efficiency are very high (85% to 95%) but it is better to define system efficiency. To improve efficiency of electricity use, it is essential to look not only at electrical equipments like motors, lighting, etc. **but also for what specific end use it is used and how the total system efficiency from end use to supply can be improved.**

Typically System Efficiencies for various items could be listed as follows:

(i) Pumping system : kW Hr/1000 litres of water output
(ii) Refrigeration system : kW/ton
(iii) Air System : kWh/m^3 (or CFM)
(iv) Heating melting : kWh/ton of heat treated or melted
(v) Illumination : Delivered lumens/watt
(vi) Electrolytic process : kWh/kg
(vii) Plant level : kWh/ton or product or kWh/meter of cloth

The approach of every organisation has to be to improve system efficiency which is a product of efficiency of all parts. Thus providing energy service to an organisation at an optimum cost becomes the part of "Energy Management". As a starting point of "energy management", **the energy audit becomes a tool for the issues related to "improvement of efficiency and energy conservation".**

4.4 Energy Audit

4.4.1 It is normal practice in a company to carry out financial audits for management control purposes, for example budgetary control, cash flow data and annual accounts With today's energy costs it makes sense to treat them as a separate item and not include them in the overheads.

An energy audit will help to understand more about the way energy is used in the organisation and help control energy costs by identifying areas where waste can occur and where scope for improvement may be possible. An energy saving in an organisation could mean increased profits, more competitive pricing. An energy audit would enable you to identify waste of energy and reduce the cost.

4.4.2 The original meaning of the word `Audit' is a "check or examination of an account". In our case term `Energy Audit' refers to a - " plant energy study or an Energy utilisation analysis" of a plant. Such a study comprises the collection of energy data of plant, the suitable presentation of data and their evaluation with respect to possible energy savings.

Energy cannot be saved until it is known `where and how it is being used and when and where its efficiency can be improved by establishing a baseline.

In most cases, the establishment of this baseline requires a comprehensive and detailed survey of energy uses and losses , this survey is generally known as the energy audit

4.4.3 There are conventional energy conservation methods but these lack a co-ordinated plan of action. Consequently only apparent systems are treated. Further system interaction is not analysed and what may conserve energy in one area may lead to problems in others. Energy Audit, on the other hand, involves a total system approach and aims at optimising energy use efficiency for the entire plant

4.4.4 An energy audit is an instrument to save energy, in order to reach this aim, the quantity and quality of the energy input and energy consumption have to be considered. In a system, no energy is `lost' but quality of energy decreases. We simply call such loss of quality an "energy loss"

Energy audit is not an exact science This involves collection of data and analysis. **But the interpretation requires detailed technical knowledge, experience and a sound judgement.** It is evident that one has to use sophisticated instruments, to collect the data. In energy audit, a formal in-depth review of the plant, a professional study by competent specialists in the field of energy to develop and evaluate ideas for improving energy efficiency in a systematic way. This also helps in identifying wasteful areas.

4.4.5 Relation of Energy Audit and Energy Management

Energy audit, which is a prerequisite for any energy management programme, is essentially an attempt to balance the total energy inputs of a plant with their use. It identifies the areas where conservation potential exists. Any organisation which wishes to reduce energy costs must have a chain of "energy management programmes" and energy audit acts as a vital link in that chain An energy audit is not something which is done once and for all ; it is on-going process of comparisons between theory and practice leading to an ever-improved understanding of what energy is being used, why energy is being used, how it is being used and at what cost.

4.5 Thus the "Energy Management" Includes :

a) Development of an energy information system. This should lead to monitor, control and forecast consumption of various forms of energy, costs of various forms of energy. relation of energy consumption to production and optimising production costs

b) Short term and long term planning for energy needs of an organisation (keeping availability and prices of different fuels of energy)

c) **Preparation and execution of a plan for improving energy efficiency and energy conservation.**

d) Keeping track of legal, safety and environmental factors related to energy use.

e) Development of human resources to take care of energy management.

Thus, energy audit carried out will help in preparation and execution of a plan for **improving energy efficiency and energy conservation.**

4.6 Scope of Energy Audit

4.6.1 The first step in understanding how to save energy, it is necessary to know where, how and how much energy being consumed. This in short could be called **plant energy study**. All energy that enters and leaves a plant during a given period must be measured.

4.6.2 The use of energy have to be quantified within the plant at various levels in departments. The plant energy study provides a comprehensive and detailed picture not only of the type and quantity of energy being used **but also how efficiently it is being utilised and where it is wasted or lost** .

4.6.3 The energy audit process include description of energy inputs and product outputs by major dependants or by major processing functions and will evaluate the energy efficiency of each step of the manufacturing process. Means of improving these will be listed, and a preliminary assessment of the cost of these improvements will be made to indicate the expected payback on any capital investment needed.

4.6.4 Energy audits facilitate the energy savings potential, identify the individual energy savings measures to be taken and estimate their investment cost and impact on operating costs. Depending on the energy consumption level of each facility, on the complexity of the plant energy distribution and utilisation systems, and on the objectives perused, several types of audits can be designed

4.7 Methodology and Approach for Audit

4.7.1 There is no set methodology which can be readily tailor adopted for conducting energy audit in all plants It depends on the management philosophy, history and culture of the organisation, type of plant and machinery, technological and process intricacies etc , However the general outline for energy audit approach and methodology could be described which will help the individual plant to formulate a plan for energy audit appropriate to its operations, set-up and needs.

4.7.2 Having conducted an energy audit does not, however, constitute in itself an energy conservation programme. A number of other conditions must also be met

(i) First, there must be a will to save energy.

(ii) Second, viable projects must be evaluated according to the company's financial guidelines.

(iii) Third, financing must be available, and

(iv) fourth, plant management and staff must be committed to continuing the energy rationalisation effort well beyond project implementation, as the benefits of good projects can be lost as quickly as they are gained.

4.7.3 In case of BWSSB, the broad scope of energy audit among other things covered the following

Energy audit of Cauvery Pump houses stage, I, II & III
Energy audit of Arkavathy scheme pump houses
Energy audit of City distributory system pumping houses
Long term measures for new ventures to incorporate efficiency parameters

4.7.4 A team of four consulting engineers from TERI were involved in the energy audit study. During the survey, all the installations were visited and studied in detail. During study, every attempt was made to understand the operational and technical feature of each installation.

Detailed measurements were taken wherever necessary/possible using TERI instruments and collected the required data. BWSSB too had spared their flow meter which was very useful for measuring velocity of main manifolds which have a large diameter of 1200 mm/1750 mm.

a. Data Collection

This included equipment details like :

- Power supply inputs and electrical data
- Pump, motors, starters and cable connections
- Capacitor bank
- Water supply input and output details
- Operating parameters of station
- Throttling of valves
- Problems encountered.

The electrical data collected included maximum demand, units consumed, control functions, review of maintenance records, instrumentation, capacity of equipment, efficiency figures, loading of equipments.

b. Trial Runs/Tests

Trial runs / tests were conducted at each installation to assess efficiency figures applicable for pump sets

c. Hydraulic kW required and Combined Efficiency

The hydraulic kW required to raise the water to desired head and combined efficiency of pump-motor was evaluated

d. Data Analysis

The data collected, measurements taken and test carried out have been used in the analysis. The various factors considered for analysis are generally as follows

- Operating load
- Energy consumption pattern
- System efficiency
- Specific energy consumption with regard to name plate details.

During the audit, the data collected were used with existing support materials (such as chart/tables, etc , which helped in validating results of check and has been used in building energy balances, first for each piece of major equipment and then for the whole station. From such an energy balance, it was possible to determine the operating energy efficiency of the equipment/station and identify scope for improvement.

This analysis helped in identifying

- Sizing adequacy of motor with regard to pump capacity/head
- Efficiency parameter analysis
- Power factor improvement
- Transformer loading
- Renovation of modernisation aspects

As a next step of analysing the data, concentrating on identifying costs and benefits of selected options (actions, investments) was made for each opportunity Thus, the energy audit report submitted covered the audit recommendations and implementation characteristics (timing, benefits, etc.).

CHAPTER - V

SUMMARY OF ENERGY SAVING OPPORTUNITIES IN CASE OF BWSSB STATIONS

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SUMMARY OF ENERGY SAVINGS OPPORTUNITIES IN CASE OF BWSSB STATIONS

I. CAUVERY PUMPING STATIONS

5.1 Energy Saving Potential

Based on the detailed observations & analysis, potential energy saving was identified The techno-economic feasibility to implement every measure was studied in detail. The various measures requiring the investment are as follows:

A. Combined efficiency performance figures & replacement of existing pumps wherever required:

i Stage-I pumps for 3 stations
ii Stage-II pumps for 3 stations
iii Recommended replacement time table

B. Renovation/modernisation of water works

i Protection, relay and metering
ii. Annunciation panels
iii Changing of 'MOCB' of motor starter panels of stage-I

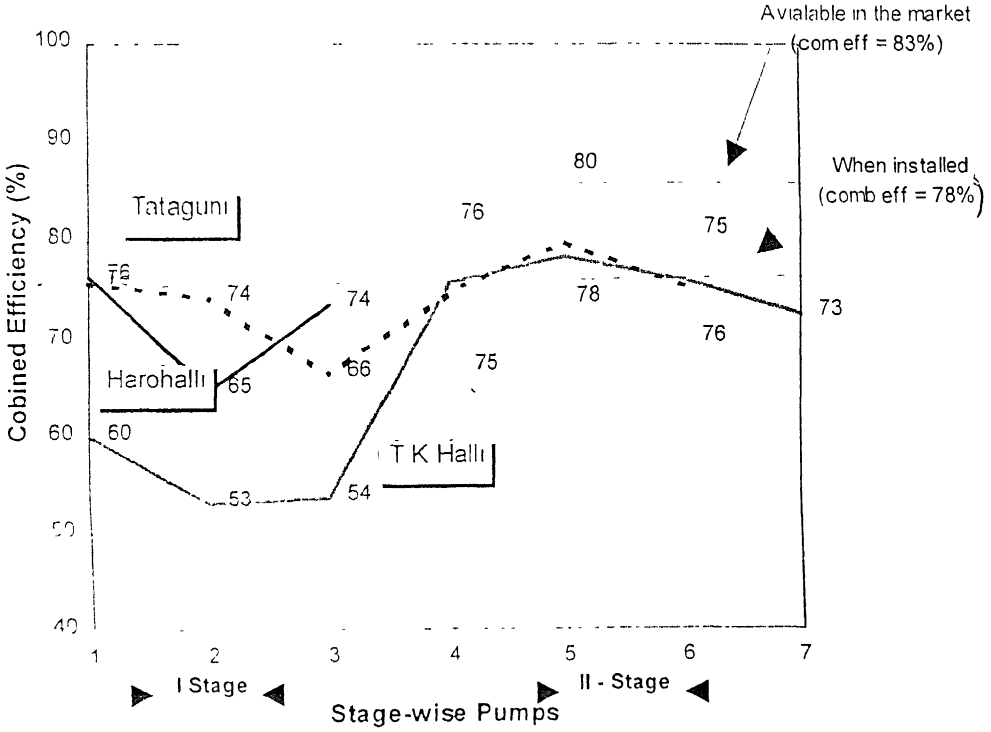
5.2 Summary of Observation in a nut shell for power/discharge and efficiency

Station	Stage I				Stage II				Stage III			
	Pump No	Actual kW	MGD	Combined Efficiency	Pump No.	Actual kW	MGD	Combined Efficiency	Pump No.	Actual kW	MGD	Combined Efficiency
T K HALLI	3	1263	9.37	59.93	7	919.8	8.64	75.85	1	1257.6	12.82	87.56
	4	1202	7 87	52.92	8	964 8	9.37	78.45	2	1248.0	12.93	88.98
	5	1278	8 48	53.63	9	928.8	8.73	75.91	3	1267.2	13.42	90.94
					10	927.0	8.33	72.60	6	1286.4	13.53	90.31
									8	1262.4	13.64	92.77
		Manifold	**24.68**	**53.17**		**Manifold**	**32.54**	**68.94**		**Manifold**	**63.62**	**86.42**
HAROHALLI	1	1095.26	10.34	76.31	7	979.2	NP	NP	2	1619	13.47	69.34
	3	1065.60	9.47	64 91	9	1108.8	NP	NP	4	1271	13.36	87.62
	4	1062.00	10.68	73.54	10	1112.4	NP	NP	5	1269.6	13.42	88.07
									6	1266	13.21	86.89
									7	1268	13.58	89.25
		Manifold	**27.87**	**69.86**		**Manifold**	**27.77**	**65.65**		**Manifold**	**67.52**	**61.54**
TATAGUNI	1	1042.2	9.77	75 70	9	1022.4	10.41	74.77	2	1221 6	13.13	89.57
	3	1024.2	9 40	74.14	8	1067.4	11.14	79.89	4	1221.6	13.45	91.72
	4	1054.8	8 67	66.38	10	1069.2	11.45	75.39	6	1250.0	13.05	87.02
									8	1216.8	12.71	87.09
									5	1236.0	13.25	89.37
		Manifold	**26.27**	**67.98**		**Manifold**	**28.32**	**69.70**		**Manifold**	**62.28**	**82.83**

5.3 Combined Efficiency Performance Figures

Station		Combined Efficiency Figures %		
		Stage-I (1974)	Stage-II (1982)	Stage-III(1993)
Age of pumps		(23 years)	(15 years)	(4 years)
Present level of efficiency	T K Halli	54-60	72-78	87-93
	Harohalli	65 - 76	-	87-89 (except pump)
	Tataguni	66 - 76	74 - 78	87 - 89.5
When installed, ηm = 94 5% & ηp = 82%		78	78	84.5
% dip in η from installed date		18-24(T K) 2-13(Others)	Upto 6	N A
New Pumps available now ηm = 94 5% & ηp = 88%		83	83	83
% dip in η compared to present day pumps with ηm = 94 5 % & ηp = 88%		23-29 (T K) 7-18(Others)	Upto 11	N A

m = motor, p = pump



The dip in efficiency figures in stage-I pumps of T K Halli is in the range of 18-24% and 2-12% for other two stations. For stage-II pumps the same is upto 6% However, when compared to best efficiency figures pumps available presently in the market, these figures will go upto 29% for T K Halli stage-I and upto 13% for Tataguni & Harohalli Stage-I, Stage-II pumps. The major problem of pumps noticed for Stage I & II stations include holes in the impeller (replacing them), vibrations, bearing problems shifting/shaft gland packing etc.,

5.2.1 The Board was meeting electricity tariff in the following manner:

Demand charges	=	Rs 100/- per kVA
Energy	=	Rs. 2 00 per unit (including fuel escalation and taxes)

Since the BWSSB's capacity factor/availability factors are 100% and operating power factor is say 0.85, the equivalent tariff would be :

$$\text{Tariff}_{(\text{Demand + Energy})} = \frac{100}{(0\ 85)X(24)X(30)} + 2.0$$

$$= 0\ 16 + 2 = \text{Rs}\ 2\ 16$$

5.2.2 The rough estimate or economics of replacing all the pumps by more efficient pumps could be projected as follows (typical)

- The cost of each pump would be around Rs 15 lakhs after considering the salvage value of old pump
- The present annual electricity cost for stage-I pumps could be estimated at
- At T K.halli 3Nos x1250kWx8760hrsx2 16(tariff)= 236 52 (actual)
- At Tataguni : 3 Nos x1050 kWx8760 hrs.x2 16 = 596.03 (actual) & Harohalli

5.3 Stage-I (23 years old) (Three Main Stations of Tataguni, Harohalli & T K Halli) :-

5.3 1 When pumps were installed during 1974, the manufacturer's test certificate indicate that under given head, discharge & system configuration, these motor-pumps set can have best efficiency figures of 78% (motor· 95%, Pump: 82%) Presently the pumps at Tataguni & Harohalli stations have efficiency range of 65-76% i e. 2-13% less than best efficiency figures expected.

In case of T K Halli these figures being 54-60%, i.e. the dip in efficiency figures is 18-26%. Thus these figures help to prove that it is necessary to replace the pumps with more efficient ones The motors installed for these station were with highest efficiency figure of 95% and are comparable to the one available in the market now also. In case of stage-I motors of M/s.BHEL, there are no failures with them so far and efficiency figures for such sized HT motors is almost constant beyond 50% of the load Thus there is a much better chance to get a more efficient pump. In case of pump, with the improvement in design, presently in the market pumps of 88% efficiency is available, as against 82% for these when installed (stage-III have similar high efficient pumps)

This is higher by 6 1% The major problem of pumps noticed for Stage I & II stations include holes in the impeller (replacing them), vibrations, bearing problems shifting/shaft gland packing etc ,

5.3.2 If new pumps with best efficiency of 88% is purchased, the minimum improvement in % efficiency of different stage pumps could be estimated be as follows

Station	Max. Possible Improvement		% minimum improvement expected	
	Stage-I	Stage-II	Stage-I	Stage-II
T K Halli	23 - 29	11%	20%	8%
Harohalli & Tataguni	7 - 18	11%	7%	8%

5.3.3 Assuming that the new system purchased saves 20% electricity, in case of T K Halli and 7% in case of other two stations **(conservative figures),** the saving on electricity per year to finance new system, if one least efficient pump is changed, would be as follows:

$$3 \times 1250 \times 8760 \times 2\ 16 \times \left(\frac{100}{60} - \frac{100}{80} \right)$$

$$3 \times 1250 \times 8760 \times 2.16 \times 0\ 41= \quad \text{Rs. 290 91 lakhs}$$

5.3.4 Similarly in case of stage-I of Tataguni and Harohalli as maximum efficiency improvement expected is around 7%, the savings will work out to Rs.73 8 lakhs, if all five pumps are replaced.

As such replacement of all the five pumps in I-stage will account for maximum benefit by way of annual savings of energy will be to the extent of Rs. 290 91 lakhs/annum Apart from this, the higher discharge upto rated capacity of 30 MGD of water is expected as against upto 10% less presently. The investment will be Rs. 75 00 lakhs for 5 pumps for each stations i.e for 3 stations of I-stage pumps (15 nos), the investment will be Rs 225.0 lakhs

The electricity tariff has been increased from August 97 by KEB. Considering the same. unit cost will be Rs 2 43 per kWh (as against Rs 2.16 now) or 12 5% rise, the minimum annual savings towards energy cost will reach a figure of Rs 327 27 lakh for T K Halli - Stage - I pumps and Rs 83 02 lakh for Stage - I pumps of other two stations of Harohalli and Tataguni As the efficiency figures of individual pumps are known, the energy savings in each station is worked out separately

5.3.5 II Stage pumps for three stations (15 years old)

As per the manufacturer's test certificate i.e. the best combined efficiency figures of 78% and the pump characteristic of I & II stage are almost comparable. The present level of combined efficiency figures of these pump-motor set are 72-78%. Considering 84.5% as the possible efficiency figures achievable, the improvement of 7 to 13% is possible. Failures of motors is also reported. Each re-winding of motor may bring down the efficiency level up to 1.5% depending upon the re-winding quality. Considering the margin to be allowed for dip in efficiency of motor, there would be atleast 8% improvement **(conservative estimate)** in overall efficiency, if these pumps are replaced by new ones with 88% efficiency pumps which are available in the market.

The electricity consumption pattern of pumps at II stage of all the three stations of Tataguni, T K Halli & Harohalli are in the range of 1020 - 1110 kW. Thus after opting for new pumps with 88% efficiency, the saving in energy per annum would be as follows

$$\text{Savings} \qquad \underset{\text{Nos}}{3} \times \underset{\text{kW}}{1050} \times \underset{\text{h}}{8760} \times \underset{\text{tariff}}{2.16} \times \underset{\eta \text{ figures}}{\left(\frac{100}{72} - \frac{100}{80} \right)}$$

$$3 \times 1050 \times 8760 \times 2.16 \times 0.135$$

$$= \text{Rs. } 80.46 \text{ lakhs}$$

Considering the revised electricity tariff of Rs 2 43 per unit applicable from August 1997, the cost of savings of energy will go upto Rs.100.57 lakhs.

5.3.6 Thus, the maximum savings on electricity energy per annum with replacement action could be as follows (considering conservative figures only).

Station	Stage-I	Stage-II	Total
T K Halli	230.91 (327.27)	80 46 (100.57)	311.37 (427.84)
Harohalli	73.8 (83.02)	80.46 (100.57)	154.26 (173.54)
Tataguni	73.8 (83.02)	80.46 (100 57)	159.26 (183.59)
Total			**619.89** **(697.37)**

(Bracketed figures are with revised tariff of KEB)

Thus a minimum benefit of Rs.619 89 lakhs, an energy savings annually is expected (Considering revised tariff, this figure will reach Rs.697.37 lakh).

In the above analysis, **conservative figures** have been assumed. However, actual energy savings based on efficiency figures of individual pumps could be calculated separately.

5.3.7 Stage -III Pumps (4 years)

The efficiency figures of stage-III are very satisfactory and no further analysis is considered necessary. Based on the efficiency figures derived, it appears that system characteristic is well matched when 5 pumps are operating in parallel. This has accounted for higher discharge for each of the pump and higher efficiency figures than available in the test certificates

5.3.8 Recommended Replacement Time Table

As there are totally 30 pumps in the group of stage-I & II stages, the replacement could be done in two years time as detailed out below..

Year
I : 15 nos (All I-Stage Pumps)
II : 15 nos. (All II-stage pumps)
Total 30 nos.

The cost and savings on the above schedule would be:

Year	Investment Required	Minimum Savings in energy expected Rs. in lakhs/year
I year	225	**378.51**
II Year	225	**378.51 + 241.38 = 619.89**
Total	450	**619.89* (Thereafter every year)**

** with revised KEB tariff, this figure will go up to Rs.697.37 lakh.*

5.3.9 Uniformity of Equipments (PUMPS)

Uniformity of equipments (pumps) among the stations is a must, especially considering such a large installation. Hence, the procurement action is proposed by initiating a combined tender enquiry and finalised with a single firm but with a spread delivery schedule to suit the two years period.

The above measure is expected not only to achieve savings in electrical energy but also improve the water flow to the required level of 30 MGD from each transmission mains, with checking on NPSH requirement and availability.

5.4 Renovation/Modernisation of Water Works

Certain areas of water works require immediate attention towards renovation/ modernisation. The important areas identified are listed in brief.

5.4.1 Protection, Relay & metering schemes

Presently motors protective relays/metering are of electro-mechanical type. The relays have become sluggish, spare parts are also not readily available after change in technology Hence they should be changed to latest technology version **'microprocessor based digital'** type relays for motor protection. These relays also deal with the important management aspects such as on-line monitoring of motor input parameters, post-trip parameters, acquisition, historic information on motor including no. of trips etc , the protection also covers thermal overload, short circuit, earth fault, unbalanced current (phase failure, inter-turn short circuit), prolonged start, loss of load, too many starts etc.

The individual motor-pumps should have three important measurements in the panel.

- Electrical Energy consumption (electronic version)
- Water velocity & discharge (integrating type for discharge)
- Pressure readings across the pump (Inlet & Outlet)

The station/stage wise, there should have totalizers for

- Electrical Energy (Electronic versions)
- Water & discharge (Integrating for Q) for pumps/manifold
- Pressure for main manifold

In case of these parameters made available over a period of time, would help analysing on specific energy consumption pattern and flow of water to the next station These parameters could help analysing the present condition and deterioration levels etc , of pump-motor sets incoming years, for aiding in quick decision making

As the concept of on-line computerisation is now available, is preferable to automise atleast above parameters

Presently for the transmission mains existing facility for reading pressure/ cumulative flow are not fully operative.

It would be necessary to have such facility at the last point where main transmission line ends/or branches off. The location identified are listed below.

city entry point for main transmission- I	Mains-I
city entry point for main transmission - II	Mains-II
city entry point for main transmission -III at high ground station	Mains-III
Energy points of Harohalli Tataguni (3 main in each stations)	6 nos.

These entry point measurements will given overall idea of pressure/comparative cumulative discharge at the end of the transmission mains

5.4.2 Annunciation panels

Annunciation panels provided in all the 3 major stations (stage-I, II & III) are not operating, thereby the assistance required for the day-to-day operation to the plant operators is not available Presently in the market micro-processor based annunciator panels are available which have reliability of 100% and the same could be procured Even events of outdoor yard equipments could be integrated Thereby the operator desk/panel for Annunciation (common to station) could be integrated for stage I&II and one more for stage-III.

5.4.3 Soft Starters

Presently, the start-up gear for 6 6 kV HT motors is with auto-transformer However, several failures of start-up auto transformers are noticed, thereby requiring the urgent measures to replace with latest technology of 'soft starter' features Though, electronic version are costly, the alternative technology of flux compensated, non-saturated, magnetic amplifiers for controlling the motor start-up current/ torque during acceleration are available, at most competitive rates in the market

The advantages of using any 'soft starter' for such HT motors could be :

a. Smooth starting by torque control for gradual acceleration of the drive system (thus preventing jerks and extending the life of mechanical components).

b. Reduction in starting current (thus preventing mechanical, electrical, thermal weakening of the electrical equipment such as motors, cables, transformers and switchgears).

c. Enhancement of motor starting duty by reducing the temperature rise in stator windings and supply transformer.

Though there may not be quantifiable energy saving on this account but other benefits are :

- helps in suppressing of high kVA demand at start-up time
- mechanical & electrical shock will be reduced thereby avoiding weakening of equipment This is very important considering 30 years of life of motors and other connected equipments.

5.4.4 Changing of MOCB of Starter Panels of Stage-I

6.6 kV breakers of starter panels are of 'MOCB' type which are out dated/unreliable. The confidence level of operators is very less on this account. Hence, it is suggested to change there 'MOCB' breakers for 'run breaker' of stage -I panels to 'vacuum breakers'

II. CITY DISTRIBUTION PUMPING STATIONS

5.5 Energy Saving Potential

Based on the detailed analysis and observations the potential for energy saving were identified. Various energy conservation measures were arrived at to reduce the energy consumption and improve the efficiency. The techno-economic feasibility to implement the measure was studied in detailed. The various measures recommended are.

i) Improvement of power factor
ii) Replacement of existing standard efficiency motor/pump by high efficiency motor/pump
iii) Improving metering system

The above summary of recommendation for various stations are listed below:

5.5.1 Improvement of Power Factor

The operating power factor some of the distribution stations were observed at the bus level. Some of the existing capacitor banks are in operative due to various reasons It is estimated that with the improved pf 167 kVA energy cost of Rs. 2.0 lakh per annum could be saved. A summary of savings on improvement of power factor is shown below:

Sl No	Pumping Station	Demand Savings			Investment Rs	Simple payback period years
		kVA	Rs.per month	Rs. (lakhs)/yr		
i	Highground (4X100HP)	47	4700	0.56	Existing capacitor bank to be repaired	Immediate
ii	LLR (3X100HP)	23	7,000	0.27	12,000	5 Months
iii	Hosahalli Motor No.1 (250 HP)	70	300	0.36	Existing capacitor bank to be repaired	Immediate
iv	OMBR	3		0.47	4,500	1 year 3 months
v	BEL Pump House Malleswaram	3	3000	.036	1800	6 months
vi	Yelahanka Pump House	4	400	.048	2400	6 months
vii	HGR & KGT	17	1700	0.20	10,500	6 months
	Total	**167**	**16700**	**2.00**	**31200**	

5.5.2 Replacement of existing standard efficiency motor/pumps by high efficiency motor/pump.

This is based on the following criteria:

- the motor-pump sets which works for 24 hours continuously
- If the motor-pump set is of more than 15 years old and efficiency is low (less than 50%) for 8 hours of operation.

The techno-economic feasibility of replacement of such sets will result in savings to the tune of 36.43 lakhs units annually costing Rs 72.03 lakhs.

Sl. No	Pumping Station	Annual Savings			Investment	Simple payback period years
		Demand (kVA/m)	Energy (L.kWh)	Rs. (lakhs)	Rs. (lakhs)	
I	Highground (4X100HP proposed replacement by 3X250 HP)	14.2	0.37	0.17+ 0.74 0 91	Board is taking action for replacement of 100HP to250HP *	2.7
ii	LLR (3X100HP)	-	3.72	7.44	9.0	1.25
iii	Mount Joy (3 X 50 HP)	-	1 2	2.5	4.5	Less than 2
iv	Ulsoor (2 X 75 HP)	-	0.70	1.4	4.2	3 years
v	ITI (2 X 50 HP)	-	1.31	1.51	3	2.0
vi	Malleswaram CJF (4X150HP)+1X85HP+ 2X60 HP	-	19 13	38.26	14.0	0.6
vii	Hosahalli (3X250HP)	-	10 0	20.00	6 00	
	Total	**14.2**	**36.43**	**72.03**	**40.4**	

*** Board has proposed replacement action for procuring motor. It has to be high efficiency pump.**

.5.3 Improving Metering System

Metering plays a vital role in any system for better management of energy it helps in monitoring and controlling of various parameters involved in the operation. The various parameters to be monitored and controlled in water supply are·

stallation	L T Installation
nd	-
nsumption	Energy consumption
ctor	Power Factor
Time totaliser across pumps	
; surement	Same as in case of HT
er of water for individual pumps/mains	

All measurements should be recorded hourly and review daily/weekly to be made for deviation.

For nodal stations, there shall have measuring meters, so that water auditing could be done by BWSSB staff and specific energy consumption figures could be monitored continuously.

The following stations could be considered as 'nodal' stations.

a High ground Station I & II
b LLR Station
c Malleswaram Stations - HGR, KGT, GJF, Yelahanka
d OMBR Stations I & II
e Mount Joy Station
f Hosahalli Station

5.6 Summary of Potential Savings

5.6.1 For Main Pumping Stations of Cauvery Zone (Requiring Investments)

Sl .No / Measure	Unit	1 Replacement of Electro-mechanical meters with trivector meters at KEB mains	2 Replacement of existing pumps by high efficient pumps	**Total**
TATAGUNI				
Annual Savings				
Energy	(lakh kWh)	Upto 21 46	51.17	72 63
Cost	Rs. (lakh)	Upto 42.92	102.34	145.26
Investment	Rs. (lakh)	4	75	79
HAROHALLI				
Annual Savings				
Energy	(lakh kWh)	Upto 18 05	53 35	71.4
Cost	Rs (lakh)	Upto 36.10	106 6	142.7
Investment	Rs (lakh)	4	75	79

Sl .No Measure	Unit	1 Replacement of Electro-mechanical meters with trivector meters at KEB mains	2 Replacement of existing pumps by high efficient pumps	**Total**
T K HALLI				
Annual Savings				
Energy	(lakh kWh)	Upto 22 61	129.59	152.20
Cost	Rs (lakh)	Upto 45 23	258.18	304.41
Investment	Rs. (lakh)	4	75	79

Total savings at 3 stations = Rs.592.37 lakh

It can be seen from the above that the simple payback period will be only 5 months. If revised tariff of electricity is considered, the cost of energy savings will be Rs.666 41 lakh and simple payback period will come down further.

5.6.2 For City Distribution Stations proposals (Requiring Investment)

Sl. No	Measure	Annual Savings		Cost of Savings	Investment Required	Simple payback
		kVA Demand	Energy (Lakhs)	Rs. (lakhs)	Rs. (lakhs)	period (Years)
a	Improvement of pf	154	0.85	1.1	9.18	Within 2 months
b	Replacement of existing standard efficient motor/pump by high efficiency motor/pump	14 2	36 01	72.03	40.4	< 6 months
c	Improving metering system for stations	Quantification is not Possible				
	Total	**168**	**36.86**	**73.13**	**49.18**	**< 6 months**

It can be observed that the maximum simple payback period worked out is less than 6 months . If revised tariff of electricity is considered, the savings will be Rs.82.27 lakhs.

5.6.3 Thus the potential savings of BWSSB installations which requires investment will be as follows :

Sl.No.	Particulars	Per annum in lakhs	
		Units	Cost, Rs.lakh
1	Main pumping stations	296.23 units	592.37
2	For distributory stations	168 kVA+36.86 lakh units	73.13
Total			**665.50**
3	With revised tariff of KEB 12.5% rise	**Total**	**748.68**

CHAPTER - VI

PROJECT IMPLEMENTATION PROGRAMME

CHAPTER - VI

PROJECT IMPLEMENTATION PROGRAMME

6.1 Project Implementation

The implementation programme for project could be divided into number of stages starting with immediate effect Following are the stages considered in the implementation programme -

a Appoint of consultant for the identified packages
b Preparation of detailed specification of various equipment
c Identifying and pre-qualification of contractors
d. Tender Invitation
e. Evaluation of tender & Award of contract fir supply & erection
f Supply/installation/commissioning
g Overall monitoring of improvement achieved.

The maximum period of implementation as programmed is two years. In view of the nature work involved, it would be desirable to pre-qualify the contractors for the major components of the project.

6.2 Phasing of expenditure

The project is expected to start in 1997 third quarter of itself and the planned to be completed by third quarters of 1999.

The expected year-wise pattern of incurring capital Expenditure is given in table below:

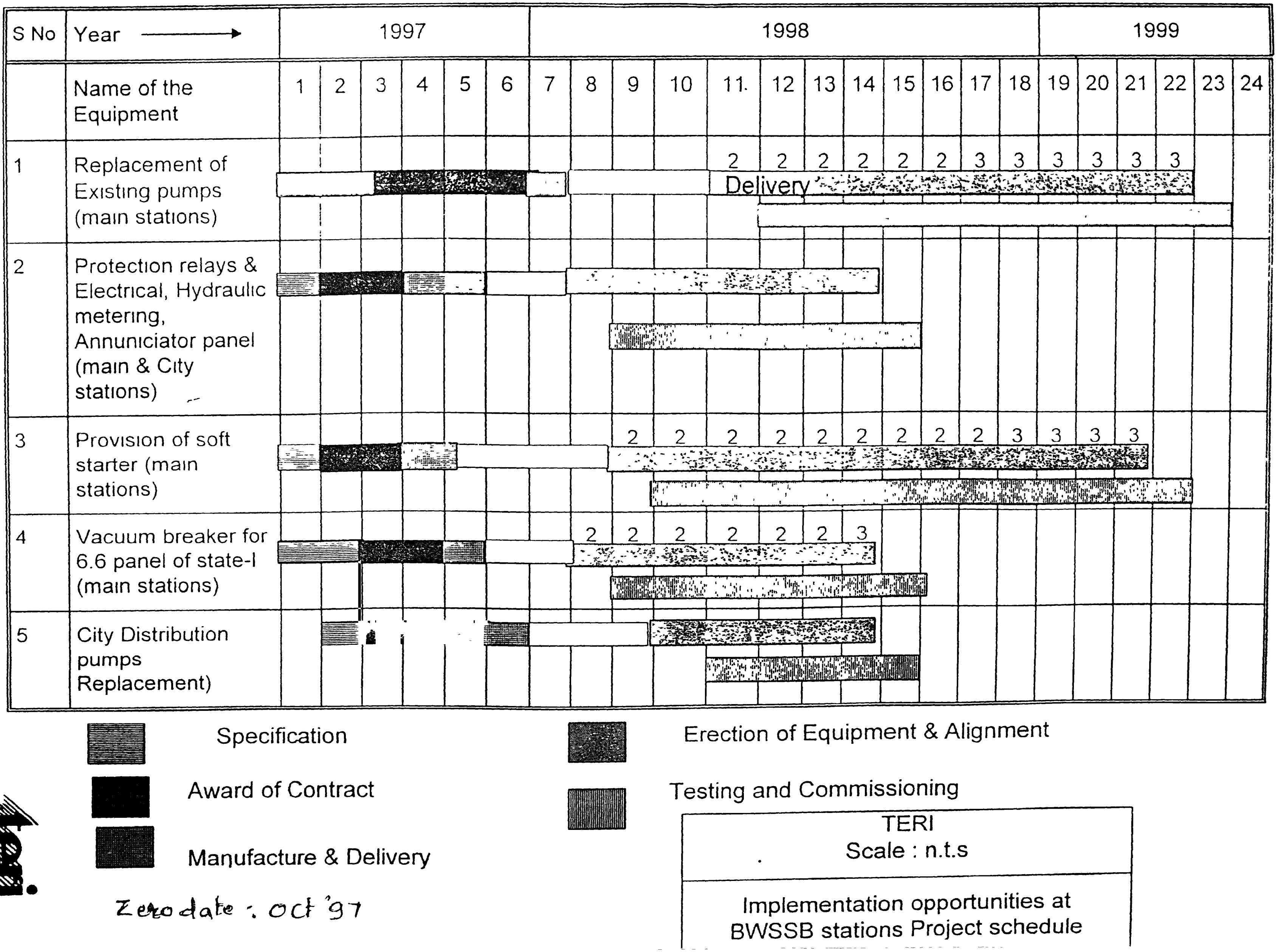
Year	First	Second
	1997-98	1998-99
Pattern of incurring capital expenditure	40%	60%

6.3 Procurement

Considering retrofit issues, it would be necessary to identify various contractors and pre-qualify them for various packages for quick execution of the project. Further, these packages can be categorised as ICB for major pumps and LCB for all other packages. BWSSB is statutory authority of Karnataka State Government under the urban Development and is responsible for the implementation the projects.

6.4 Each contract will be procured in accordance with BWSSB guidelines.

6.5 Consultancy services in specified areas of the project will have to be assigned by BWSSB with specific terms of reference.



TERI
Scale : n.t.s

Implementation opportunities at BWSSB stations Project schedule

Zero date : Oct '97

CHAPTER - VII

INVESTMENT COSTS

CHAPTER - VII

PROJECT COSTS

7.1 Project Components

The major components of the proposed investment could be grouped into two categories.

a. Areas of energy saving opportunities
b. Areas of renovation and modernisation.

7.2 Under (a) above, the action is proposed for the replacement of inefficient pumps in the system. In case of Cauvery Stages I, II & III, there are 54 nos. of large pumps which have a discharge capacity of 10/12 MGD with 160/170 m head. These pumps are driven by 6.6 kV H T Motors of 1250/1500 kW motors. Normally 33 No. of pumps run for 24 hours of the day in the 3 main stations Cauvery stations of T K Halli, Harohalli and Tataguni accounting for largest energy consuming area which is about 3154 lakhs units per annum costing Rs. 65 crores. Out of 54 nos. of pumps, 30 pumps of stage I & II of above three stations are 23/15 years old have a similar design characteristics and have now dip in efficiency upto 26%. There has been considerable improvement in the design of pumps itself in last 10 years and in the market there are further improved versions are available which give higher efficiency of atleast 6% compared to these old version pumps. Thus in case of replacement by new version pumps, there will be improvement in the efficiency level of these 30 pumps upto 29% depending upon the present level of operational efficiency. In fact, balance 24 no. of pumps of III stage of 3 main stations have a such improved design parameters and are presently operating at desired efficiency figure of 88%. Thus the replacement with such efficient pumps for stage I & II will definitely account for large amount of saving of energy.

Similarly in case of city distribution, there is a necessity of replacing in efficient pumps identified during energy audit, which are run by LT motors with capacity ranging from 50 HP - 250 HP.

7.3 Under (b) above of para 7.1, the renovation & modernisation includes for Cauvery main pumping stations of stage I & II, which are 23 & 15 years old.

i. Improvement of electrical/Hydraulic Meter in important stations/ system which are outdated & not working

ii. Replacement of sluggish protection relays/Annunciation panels.

iii. Providing 'vacuum breaker' in place of 'MOCB' breaker for 6.6 kV run circuit of Stage-I motor starter panel.

iv. Providing 'soft starter' in place of 'Auto transformer' motor start-up circuit of stage I motors

7.4 Project Cost:-

The project cost is estimated based on BWSSB guide lines.

i. Accordingly **Base Cost** is first estimated. Then the **Price Escalation** is worked out. This is considered at 10% per annum. Considering 18 months of completion, a provision of **15% on base cost has been taken.**

ii. The **physical contingency** is calculated at 5% to arrive at the project cost.

iii. The project could be split into 7-8 main contract packages as shown in the project implementation schedule. All the contracts could be LCB or ICB basis.

iv. The **total estimated project cost** at **Oct'97** price level is about **Rs. 1670/- lakhs**. This includes provision towards price escalation physical contingency supply & erection of the equipment, consutlancy in the required area, taxes & duties. No separate supervision charges has been considered, as existing O & M staff will associate with implementation of the actions proposed now.

7.5 Basis of Cost Estimate

The estimate is based on **'budgetary figures'** from the probable suppliers. In case of pump which is a major component, the cost data of stage-III works has been considered, with appropriate escalation and providing salvage value for the old pump.

7.6 Operation & Maintenance Cost:-

The BWSSB energy bills of the system, where replacement of inefficient pump is proposed, a minimum energy savings of 300 lakh units per annum is expected which could be estimated at Rs. 748 lakhs with the present level of KEB tariff (Rs.2.24 including cost of demand and taxes). This has annual saving in energy account has been considered while considering Annual O & M cost.

7.7 The following paragraphs covers the estimates for investment to be made on each of energy saving potential identified.

All figures in Rs. Lakhs

Sl. No.	Particulars/Specification	Qty.	Unit Rate	Total Amount
A.	**Replacement of inefficient pumps at Cauvery Main Stations :**			
1	**Replacement of existing 10 MGD/170 mtrs**			
i	In efficient pumps of stage - I & II of all the three stations of T K Halli, Harohalli and Tataguni by best efficiency pumps available in the market with efficiency of figure not less than 88% at rated discharge & operating head conditions	30 Nos.	15.00	450.00
ii	Labour cost for dismantling of existing pumps, erection of new pumps including foundation works, alignment and commissioning works at 15% of above	30 Nos.	2.25	67 5
	Sub total 0f (A)			**517.50**

Sl. No.	Particulars/Specification	Qty.	Unit Rate	Total Amount
B.	**Protection relays and metering at Cauvery zone main stations :**			
2.	**Electrical Metering**			
i	At individual H.T motor control panel of Stage I & II providing of Microprocessor based multi task energy monitoring system to monitor electrical parameters like V, A. Hz, kVA, kW, kVAr, PF etc., run hours, interruption, storing of energy data for previous pilling period, % total harmonic distortion, suitable for existing C.T & P T input, RS 485 output provision, Real time clock, accuracy class 1, 7 digit, 7 segment LED (similar to ENERCON model - EM3360)	30 Nos.	0.30	9.0
ii.	Microprocessor based demand controller at 6.6 kV receiving panel (Similar to ENRCON Model EM-3460) with limit setter, advance warning, spare load, potential free contacts, real time clock, accuracy 0.5, 7 digit, 7 segment, with RS 485 serial port	12 Nos.	0 50	6.0
ii.	eDAS Consisting of ELAN PC - Software multiline to connect energy monitoring system pulse output to PC with suitable connectors, kit data converter, 3000 mtrs cables etc (1 set for Tataguni, Harohalli, & 2 sets for T K.Halli)	4 sets	1.5	6.0
iv	PC & Printer to the eDAS system	4 sets	1.0	4.0
v	Labour cost for fixing and commissioning of items (i) to (iv) at 15%	LS	-	3.75
3	**Hydraulic Metering**			
i	Resistance element for existing manometer tube and differential pressure transmitter, (DP psig - 2000 psig electronic LED indicator cum totaliser (counter) for existing ventury meter at Stage I, II and III. These shall include current converter (1 Amp to 4 to 20 mA) with suitable piping, cabling testing and commissioning.	9 sets	2.0	18.00
ii	Providing of electronic version of flow meter, indicator cum totalizer for each pump output side, piping cabling including testing & commissioning along with required transducers	30 sets	0 75	22 50

Sl. No.	Particulars/Specification	Qty.	Unit Rate	Total Amount
iii	Provision of electronic version of flow meter indicator cum totaliser for city entry transmission mains I, II, III and entry point of T.K Halli, Harohalli and Tataguni	6 sets	1.50	9.0
iv	Providing electronic digital version pressure gauge across and differential pr.gauge the inlet and outlet pipeline for one pump in each phase 1, II & III and also 3 city main entries including testing and commissioning	12 Nos.	0.70	8.40
4	**Protection relays**			
i	Supply and installation of relays for HT motor panel (replacement by microprocessor based PRO control version relay in place of existing electromechanical relays)			
	Stage I + II	30 Nos.	0.75	22 5
	Stage III	24 Nos.	0.75	18.0
5	**Annunciator panel**			
i	Supply of microprocessor based annunciator panel to the centralised control room one set to cover Stage I & II and also separate panel for stage - III (At T K.Halli, 2 Nos. at Haro Halli & T K Halli)	7 sets	2.85	20.0
ii	Wiring from new relays and meters to the annunciator panel using old cables available / additional cables etc. laying and commissioning of annunciator panels			
	Sub Total of (B)			**147.15**
C. Other Modernisation Actions				
6	Providing of **'soft starter'** in the motor starter circuit for Stage I & II 6 6 kV HT starter panel			
i	supply and commissioning (flux compensated non saturated, magnetic amplifiers type) replacing existing auto transformer of stage I + II	30 Nos.	8.0	240.0
7	**Changing of 'MOCB'**			
i	Changing of existing 'MOCB' breaker of 6.6 kV panel by 'Vacuum' breaker (in the run circuit only) of stage-I works (including replacement cost)	15 Nos.	3.5	52.50
	Subtotal of (C)			**292.50**

Sl. No.	Particulars/Specification	Qty.	Unit Rate	Total Amount
D. City Distribution for Pumping Stations				
8	Supply and installation of LT capacitor banks at			
	(i) LLR 2x20 kVAr Cost			
	(ii) OMBR 15 kVAr 0 12			
	(iii) BEL 6 kVAr 0 05	LS	-	0.31
	(iv) Yelhanka 8 kVAr 0 02			
	(v) HGR & KGT 8 kVAr 0 02			
9	Replacement of existing standard efficiency motor/pumps by high efficiency motor/pump			
	(i) LLR 3x100 HP 9 0			
	(ii) Mount Joy 3x50 HP 4.5			
	(iii) Ulsoor 2x75 HP 4.2			
	(iv) ITI 2x50 HP 3.0			
	(v) Malleswaram 4x150 HP 1x 55 HP 20 2x 55 HP	LS	-	46 40
	(iv) Hosahalli 3x250 HP 6			
	b) Labour cost for the above works @ 15%			6.96
	Sub Total of (D)			**53.67**
E. Improvement of Metering System at City Stations				
10	Electrical metering			
i	Digital Multi data meter for measuring voltage, current, kW, pf (similar to model mdm of new Horizon INC) and digital energy & power meter (similar to model micro :) (Tectrex) to each of the distribution panel at the following stations including labour cost for mounting, testing & commissioning High ground Station I High ground Station II LLR pump house (3x100 Hosahalli Yelhanka (at Malleswaram) 3 Malleswaram CJF (old stations)	10Nos.	0.30	3 0

Sl. No.	Particulars/Specification	Qty.	Unit Rate	Total Amount
11	**Hydraulic Metering**			
i	Electronic version of flowmeter cum totaliser for each station outlet piping of important pumphouse including testing and commissioning High ground - 4 Nos Malleswaram - 4 Nos LLR - 1 No Hosahalli - 2 Nos Mount Joy - 1 No	12 Nos.	0 70	8 4
	Sub-total of (E)			**11.80**
F	**Provision towards excise duty and taxes on the pumps / instruments @ 20% overall for various items**			**204.52**
G	**Grand Total (A + B+ C+ D +E + F)**			**1227.14**

7.8 Summary of the Project cost details are as follows:

A. Replacement Inefficient Pumps at Cauvery Stations. *All figures in lakhs*

1. Replacement of existing [illegible] MGD/170 Mtrs in efficient pumps of all 3 stations including labour cost

Sub total of (A) - 517.5

B. Protection relay and metering and annunciator improvements (microprocessor versions) with taxes and duties

2.	Electrical metering	- 28.75
3.	Hydraulic metering	- 57.90
4.	Protection relays	- 40 50
5	Annunciator panels	- 20 00
		-147 50

Sub total of (B) - 147.50

C	*Other Modernisation Actions*			
6.	Providing soft starters for motors	- 240.00		
7.	Changing of existing 'MOCB' breakers by 6.6 kV vacuum breakers for 'run' circuit of motor panel of stage - I	- 45 00		
	Sub Total of (C)		**- 292.50**	
D.	*City Distribution for Pumping Stations*			
8.	Installation of Capacitor banks	- 0 31		
9	Replacement of pumps / motors by efficient ones	- 46.40		
	Sub Total of (D)		**- 53.67**	
E	*Improvement of Metering System*			
10.	Electrical System	- 2.4		
11	Hydraulic System	- 8.4		
	Sub total of (E)		**- 11.80**	
F	*Sum of A + B + C + D + E =*			
	517.50 + 147 50+292.50+53 67+11.80	*= 1022.62*		
G	*Provision of Taxes & duties @ 20%*	*= 204 52*		
H	*Grand Total*	*= 1227.14*		*= 1227.14*
I	*Contingency @ 5%*	*- 61.35*		
J	*Consultation in the areas @ 1.5%*	*- 18.40*		
K	*Escalation @ 10% A for 18 months*	*- 184.07*		
L	*Interest capitalisation @11% on 50% cost*	*- 171 73*		
M	*Rounding off*	*- 7.31*		
	Sub total of (I + J + K + L + M)			*= 442.86*
	Grand total of Project			*=1670.00 Lakh*

CHAPTER - VIII

FINANCIAL EVALUATION

CHAPTER - VIII

FINANCIAL EVALUATION

8.1 Introduction

Investment in energy conservation schemes results in reduced operating costs and increases savings, and, therefore should be treated as any other capital investment The principle underlying all types of investment, is the net return expected from the proposed investment This net return or energy savings must be evaluated and compared with the cost of the project.

There are separate methods of analysis for:

a projects which do not involve major capital investment, and

b projects involving major capital investments. In the first case, simple payback period analysis is sufficient while in the second case, more detailed methods of analysis are required, which is management's prerogative.

8.2 Modes of Analysis

There are several different ways of combing the data on cost and savings from a project to evaluate its economic performance.

Payback period is mode of analysis frequently used by plants in method provides a first level measure of profitability that is, relatively calculate

The other popular method of analysis is internal rate of return (IRR) This method follows the concept of the life cycle cost approach.

8.3 Payback

The payback (also known as the payout or the payoff) method determines the number of years for the invested capital to be offset by resulting benefits. The required number of years is termed as the payback, recovery, or break-even period. The measure is popularly calculated on a before-tax basis and without discounting (i.e., neglecting the opportunity cost of capital).

The simple payback period is usually calculated as follows:

$$\text{Simple payback period (SPP)} = \frac{\text{First Cost}}{\text{Yearly benefits - Yearly costs}}$$

8.4 In the present case the basic cost is estimated at Rs.1227.14 lakhs. The annual energy savings with the present day of KEB tariff is estimated at Rs.748.68 lakhs with this, the simple payback period works out to 1 year and 6 months.

The above estimated cost of Rs 1227 14 lakhs is also inclusive of certain aspect of renovation and modernisation aspect of the pumping station at Rs. 541.74 lakhs. In case this amount is accounted as separate identity, then the payback will be get reduced to only 1 year

The total project including basic cost. IDC, escalation, contingency etc., is estimated at Rs 1,670/- lakhs. Considering the estimated returns of the simple payback period will work out to 2 years and 3 months.

8.5 Internal Rate of Return

This method calculates the rate of return that an investment is expected to yield. The internal rate of return method expresses each investment alternative in terms of rate of return (a compound interest rate). The higher the rate of return the better the investment.

The rate of return is usually calculated by a process of trial and error, whereby the net cash flow is compounded for various discount rates until its value is reduced to zero.

8.6 In the present case, the total project cost is estimated at Rs.1670 00 lakhs to be spent in two years span It is presumed that 40% of the fund will be spent during 1st year and 60% in the second year. The replacement action of 30 inefficient pumps will also cover in the two years period. After one year, 50% of the yearly benefits will start accruing in as most inefficient are identified for replacement (I stage pumps of T K Halli) in the first year itself. Thus opportunity cost of capital will be as follows :

Year	Project cost Rs. lakh	Savings (Rs.lakh) with present tariff of KEB
0	668	-
1	1002	374.34
2	-	748.68
3	-	748 68
4	-	748 68
5	-	748 68
6	-	748.68
7	-	748 68
8	-	748.68
% of IRR		31%

However, as the electricity tariff is going to be revised annually in coming years, the benefits will be higher to that extent reflecting on higher/IRR.

8.7 FINANCIAL EVALUATION

i. The total project cost estimated at Rs. 1,670 lakhs

ii. Means of Financing:

		% Loan	Rs. Lakhs
a	Karnataka infrastructure Development Corporation	50% of cost	835
b	HUDCO	..do..	835
	Total		1670

iii. Rate of interest

KUIDC = 11% p.a

HUDCO = 16% p.a + 1% front end fee

Avg Rate 13.5% p.a

iv. Disbursement and Interest Calculation for two years period in 8 quarterly instalment

Year	Quarter	Principal amount		Interest portion		Total		Grand total of capitalised amount
		KUIDC	HUDCO	KUIDC (11%)	HUDCO (16%)	KUIDC	HUDCO	
Ist	I	104 375	104 375	2 87	4 175*	107 245	104 375	211 62
	II	104 375	104 375	5 74	8 35*	110 115	104 375	214 49
	III	104 375	104 375	8 61	12 525*	112 985	104 375	217 36
	IV	104 375	104 375	11 48	16 70*	115 855	104 375	220 23
2nd	V	104 375	104 375	14 35	20 875*	118 725	104 375	223 10
	VI	104 375	104 375	17 22	25 05*	121 595	104 375	225 97
	VII	104 375	104 375	20 09	29 225*	124 465	104 375	228 84
	VIII	104 375	104 375	22 96	33 40*	127 335	104 375	231 71
	Total	835	835	103.32		**938.32**	**835**	**1773.32**

* HUDCO interest to be paid in the next quarter and hence not capitalised

v The repayment is assumed to be made in 8 years (32 quarterly). The detailed calculation of repayment schedule with 11% interest for KUIDC loan and 16% for HUDCO has been worked out and enclosed as Annexure - I. The yearly re-payment towards principle load amount and interest taken for cash flow statement are as follows:

All in Rs. lakhs

Year	Yearly Re-payment
1st	418
2nd	383.18
3rd	358.80
4th	334.42
5th	310.04
6th	285.63
7th	261.25
8th	236.87
Total	2588.25

vi Incase entire load amount is drawn from HUDCO @ 16% interest, the re-payment schedule (principle + interest) for the period of 8 years will be as follows and are to be considered for revised cash-flow statement

Year	Yearly Re-payment
1st	613,42
2nd	569.60
3rd	546.64
4th	523.68
5th	500 72
6th	477.74
7th	454.78
8th	431 82
Total	**4159.98**

8.8 The cash flow statement considering implementation of present project of energy **conservation** only as separate identity has been worked out to quantify the benefits to the Board

CASH FLOW STATEMENT CONSIDERING BENEFITS FROM IMPLEMENTATION OF PRESENT ENERGY CONSERVATION PROJECT

Sl No	FINANCIAL YEAR YEAR	1997-98	1998-99	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008
		project Implementation		1	2	3	4	5	6	7	8	9
	INCOME											
I	KUIDC Loan	334	501	0	0	0	0	0	0	0	0	0
II	HUDCO Loan	334	501	0	0	0	0	0	0	0	0	0
III	Additional Revenue from sale of additional quantity of water after implementation	0	98.0	226	253	253	284	284	218	218	356	356
	TOTAL INCOME	*668*	*1100*	*226*	*253*	*253*	*284*	*284*	*218*	*218*	*356*	*356*
	EXPENDITURE											
I	Project Investment	668	1002									
II	Repayment of Principal and interest											
	a KUIDC	0	0									
	b HUDCO	41.75	108.55	418	383.18	358.8	334.42	310.04	285.63	261.25	236.88	0
III	Reduction in Power charges	-427	-956	-1080.28	-1188	-1188	-1306	-1306	-1436	-1436	-1580	-1580
IV	Depreciation			55.11	55.11	55.11	55.11	55.11	55.11	55.11	55.11	55.11
IV	*TOTAL EXPENDITURE*	*282.75*	*154.55*	*-607.17*	*-749.71*	*-774.09*	*-916.47*	*-940.85*	*-1095.26*	*-1119.64*	*-1288.01*	*-1524.89*
	NET SURPLUS	385.25	942.35	833.17	1002.71	1027.09	1200.47	1224.85	1313.26	1337.64	1644.01	1880.89
	In case full amount of loan of Rs. 16.70 lakhs is drawn from HUDCO at 16% interest											
	NET SURPLUS	**343.50**	**838.8**	**637.75**	**816.29**	**839.25**	**1011.21**	**1034.16**	**1121.18**	**1144.13**	**1449.02**	**1880.89**

The assumption made for preparation of project energy conservation are as follows:

i. The replacement of pumps is expected to increase water discharge by 6 MGD from Stage I and II Pumps i.e., 1% of 600 MGD present overall output. Thus additional revenue has been considered at 1% more Water/KEB tariffs are considered for revision every year upto 2000 year and alternate years thereafter. For KEB tariff 13% a raise during 1998-99 and 1999-2000 has been considered and 10% from 2000-2001 onwards at alternate years. Similarly in case of Water charges tariff rise of 15% has been considered for 1998-99 and 1999-2000 and 12% rise alternate year from 2000 - 2001 onwards.

ii. Change in O & M Expenditure is not envisaged Hence not shown in expenditure column The total project implementation period is only 2 years and funds required for the first year is 40% and balance has to be spent in second year.

The repayment schedule for KUIDC and HUDCO are worked out separately and put as Annexure-I.

As seen from the cash flow the implementation of energy conservation project will benefit the Board from the completion date itself.

8.9 Overall Cash flow statement for BWSSB

The following assumptions have been made for making overall cash flow statement for BWSSB, taking other commitment. The following assumption are made while preparing the cash flow.

- The replacement of pumps is expected to increase water discharge by 6 MGD from Stage I and II Pumps i.e., 1% higher from existing level overall output of 600 MGD Thus additional revenue of 1% has been considered at 1% more from Second year onwards

- Water/KEB tariffs are considered for revision every year upto 2000 year and alternate years thereafter. For KEB tariff 13% raise during 1998-99 and 1999-2000 has been considered and 10% thereafter.

- Similarly in case of Water charges tariff rise of 15% has been considered for 1998-99 and 1999-2000 and 12% rise alternate year thereafter.

- 10% if rise p.a has been considered for O & M cost.

- The total project implementation period is only 2 years and funds required for the first year is 40% and balance has to be spent in second year.

- The repayment schedule for KUIDC and HUDCO are worked out separately and put as Annexure-I.

- Depreciation of straight-line method has been adopted. A life cycle of 30 years has been taken for pumps

OVERALL CASH FLOW STATEMENT FOR THE BOARD

Sl No	Year	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
		As per actuals		Project Impl		1	2	3	4	5	6	7	8	9
	REVENUE													
1	Revenue from Sale of water	14016	14874	17105	19671	22621	25336	25336	28376	28376	31781	31781	35595	35595
3	Other Misc Revenues	500	550	600	650	700	750	800	850	900	950	1000	1050	1100
2	Prorate charges	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600
4	Regularisation of unauth connection	-	-	1000	750	750							950	
5	Sub Total (1 + 2 + 3 + 4)	15516	16474	19805	22221	25271	27336	27436	30576	30676	34181	34281	39144	38295
	Energy Saving Project													
6	Additional Revenue from sale of additional quantity of water if energy conservation project is implemented (6 MGD More)	0	0	0	98	226	253	253	284	284	318	318	356	356
7	Savings in power charges	0	0	427	956	1080	1188	1188	1306	1306	1436	1436	1580	1580
8	**SUB TOTAL (6 + 7)**	0	0	**427**	**1054**	**1306**	**1441**	**1441**	**1590**	**1590**	**1754**	**1754**	**1936**	**1936**
9	***TOTAL REVENUE (5 + 8)***	***15516***	***16474***	***20232***	***23275***	***26577***	***28777***	***28877***	***32166***	***32266***	***35935***	***36035***	***41080***	***40231***
	EXPENDITURE													
10	Power charges	7398	11510	13006	14697	16808	18269	18269	20098	20098	22106	22106	24317	24317
11	Estt charges & GAD	2304	2267	2494	2743	3017	3319	3651	4016	4418	4860	5345	5880	6468
12	Operation & Maintenance	1016	1829	1219	1341	1475	1623	1785	1964	2160	2376	2613	2875	3162
13	Depreciation	1106	1136	1136	1136	1136	1136	1136	1136	1136	1136	1136	1136	1136
14	Improvement reserve	108	120	132	145	160	176	194	203	223	245	267	294	323
15	Pension Fund & GIs	-	96	96	96	96	96	96	96	96	96	96	96	96
16	Interest on Loans	2325	2428	2306.6	2191 3	2081 707	1977 6	1878 7	1784 8	1695 6	1610 8	1530.2	1453.7	1381
17	Repayment of Loans	719	955	955	955	955	926 31	926 31	926.31	745 1	620.6	1096.9	1065.9	1065 9
18	Interest on Debentures	469.35	472 76	462.79	442 16	394 68	342.61	306.7	275	246 86	246 86	246 86	-	-
19	Redemption of Debentures	110	137 5	275	487	523	467.5	288	256	338	-	-	-	-
20	***TOTAL OF EXPENDITURE (10 to 19)***	***15555***	***20951***	***22083***	***24234***	***26447***	***28332***	***28531***	***30753***	***31154***	***33296***	***34438***	***37117***	***37949***
21	**SURPLUS (+)/DEFICIT (9-20)**	**-39**	**-4477**	**-1850**	**-959**	**131**	**445**	**346**	**1414**	**1112**	**2639**	**1597**	**3963**	**2282**
	Energy Conservation Project													
22	Repayment of Loans with interest			41 75	108 55	418	383	358	334	310	285	261	236	0
23	Depreciation			55 11	55 11	55 11	55 11	55.11	55.11	55 11	55.11	55.11	55.11	55.11
24	**SUB TOTAL (22 to 23)**			**96.86**	**163.66**	**473.11**	**438.11**	**413.11**	**389.11**	**365.11**	**340.11**	**316.11**	**291.11**	**55.11**
25	***NETT SURPLUS (+) /DEFICIT (-) (21 + 25)***	***-39***	***-4477***	***-1754***	***-795***	***604***	***883***	***759***	***1803***	***1477***	***2979***	***1913***	***4255***	***2337***
	Incase entire loan amount is drawn from HUDCO @ 16%	-39	-4477	-1795	-1012	409	697	572	1614	1287	2787	1720	4060	2337

As seen from the cash flow statement, there will be net surplus from the 1st year after completion of implementation of the project.

8.10 CONCLUSIONS

i. The present energy conservation project implementation is a must to have overall improved efficiency of the existing water system.

ii. The pumps performance at stage I & II of Cauvery stations have reached a state of 'non-acceptable' level inspite of replacement of major rotating elements. Thus 'life of pump' in a technical sense, has reached a level requiring corrective action only by way of replacement.

iii. For the assured performance of replaced pumps, proper guarantee from the manufacturer/supplier will be obtained by way of suitable guarantee bonds.

iv. Advance action for appointment of consultant, finalisation of specifications, calling of tenders, evaluation of tenders for identified packages will be initiated now itself, so that orders could be released against financial closure

v. With the ever-growing cost of energy, being a high head application of pumps, any saving on energy front will account as 'Direct Earning' to the Board

ANNEXURE - I

8 YEARS REPAYMENT SCHEDULING FOR KUIDC AND HUDCO

Year	KUIDC				HUDCO				Towards Total Re-Payment			Yearly Payment	Net Balance
	Principal	Interest	Repayment	Balance	Principal	Interest	Repayment	Balance	Principal	Interest	Pri + Int		
	Opening Balance			938 22	Opening Balance			835 00					1773 22
1	29 32	25 80	55 12	908 90	26 09	33 40	59 49	808 91	55 41	59 20	114 61		1717 81
	29 32	24 99	54 31	879 58	26 09	22 24	48 34	782 81	55 41	47 24	102 65		1662 39
	29 32	24 19	53 51	850 26	26 09	21 53	47 62	756 72	55 11	45 72	101 13		1606 98
	29 32	23 38	52 70	820 94	26 09	20 81	46 90	730 63	55 41	44 19	[illegible]	418 00	1551 57
2	29 32	22 58	51 89	791 63	26 09	20 09	46 19	704 53	55 41	42 67	98 08		1496 16
	29 32	21 77	51 09	762 31	26 09	19 37	45 47	678 44	55 41	41 14	96 56		1440 74
	29 32	20 96	50 28	732 99	26 09	18 66	44 75	652 34	55 41	39 62	95 03		1385 33
	29 32	20 16	49 48	703 67	26 09	17 94	44 03	626 25	55 41	38 10	93 51	383.18	1329 92
3	29 32	19 35	48 67	674 35	26 09	17 22	43 32	600 15	55 41	36 57	91 98		1274 50
	29 32	18 54	47 86	645 03	26 09	16 50	42 60	574 06	55 41	35 05	90 46		1219 09
	29 32	17 74	47 06	615 71	26 09	15 79	41 88	547 97	55 41	33 52	88 94		1163 68
	29 32	16 93	46 25	586 39	26 09	15 07	41 16	521 87	55 41	32 00	87 41	358.80	1108 26
4	29 32	16 13	45 44	557 07	26 09	14 35	40 45	495 78	55 41	30 48	85 89		1052 85
	29 32	15 32	44 64	527 75	26 09	13 63	39 73	469 68	55 41	28 95	84 37		997 44
	29 32	14 51	43 83	498 44	26 09	12 92	39 01	443 59	55 41	27 43	82 84		942 03
	29 32	13 71	43 03	469 12	26 09	12 20	38 29	417 50	55 41	25 91	81 32	334.42	886 61
5	29 32	12 90	42 22	439 80	26 09	11 48	37 58	391 40	55 41	24 38	79 79		831 20
	29 32	12 09	41 41	410 48	26 09	10 76	36 86	365 31	55 41	22 86	78 27		775 79
	29 32	11 29	40 61	381 16	26 09	10 05	36 14	339 21	55 41	21 33	76 75		720 37
	29 32	10 48	39 80	351 84	26 09	9 33	35 42	313 12	55 41	19 81	75 22	310.03	664 96
6	29 32	9 68	38 99	322 52	26 09	8 61	34 70	287 03	55 41	18 29	73 70		609 55
	29 32	8 87	38 19	293 20	26 09	7 89	33 99	260 93	55 41	16 76	72 18		554 13
	29 32	8 06	37 38	263 88	26 09	7 18	33 27	234 84	55 41	15 24	70 65		498 72
	29 32	7 26	36 58	234 56	26 09	6 46	32 55	208 74	55 41	13 71	69 13	285.66	443 31
7	29 32	6 45	35 77	205 25	26 09	5 74	31 83	182 65	55 41	12 19	67 60		387 90
	29 32	5 64	34 96	175 93	26 09	5 02	31 12	156 56	55 41	10 67	66 08		332 48
	29 32	4 84	34 16	146 61	26 09	4 31	30 40	130 46	55 41	9 14	64 56		277 07
	29 32	4 03	33 35	117.29	26 09	3 59	29 68	104 37	55 41	7 62	63 03	261.27	221 66
8	29 32	3 23	32 54	87 97	26 09	2 87	28.96	78 27	55 41	6 10	61 51		166 24
	29 32	2 42	31 74	58 65	26 09	2 15	28 25	52 18	55 41	4 57	59 98		110 83
	29 32	1 61	30 93	29 33	26 09	1 43	27 53	26 09	55 41	3 05	58 46		55 42
	29 32	0 81	30 13	0 00	26 09	0 72	26 81	0 00	55 41	1 52	56 94	236 83	
	938 21	341 06	868 80		835 01	389.32	783 66		1219 09	815 04	2588 25	2588 25	